Integration of Computer Aided Design (CAD) Technology in Apparel Design Curricula

by

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Chapter I

INTRODUCTION

Increased competition from imports has generated the use of automated design and production processes in the apparel industry. Automation of the apparel design process is facilitated by computer aided design (CAD) technology. CAD is among the many new technologies used by the textile and apparel industries to implement Quick Response (QR) as a strategy to compete with imports. CAD is used to speed up the design process by reducing the time that it takes for a designer to get a style to the production room (Sheldon, 1988).

CAD was introduced in the apparel industry in the 1960s (Wilhelm, 1983) and computerized pattern grading was the first software application used. Additional CAD software was developed and used over the next twenty-eight years. This software included CAD applications for marker making, patternmaking, cutting, and design/illustration. Although developments of CAD applications for apparel increased, the industry lacked qualified personnel to operate the sophisticated systems. Consequently, clothing and textiles programs at higher education institutions began to integrate CAD into their curricula. Colleges and universities with clothing and textiles programs and CAD systems welcomed the opportunity to prepare students for positions in the industry by incorporating CAD applications in the educational process.

Kallal and Fraser (1984) reported that larger apparel manufacturers were hiring designers with college degrees. They concluded that four year programs needed to have CAD in the curriculum to better prepare students for employment in the apparel industry. Incorporating CAD in the curriculum improves the designer's attitude toward CAD as a design tool and the acceptance of CAD in the workroom (Kallal & Fraser, 1984). Therefore, the cultivation of a positive attitude for future designers was the criteria used by the University of Delaware in the development, testing, and implementation of CAD into the design curriculum.

The integration of CAD into design curricula was also supported by Sheldon and Regan (1990) who recommended the use of microcomputers in the classroom for CAD instruction. They suggested that CAD skills learned from the use of microcomputers would transfer to industrial CAD equipment.

Belleau and Bourgeois (1991) also confirmed the importance of exposing students to state of the art technology used in the apparel industry. The integration of CAD into the curriculum at Louisiana State (Belleau & Bourgeois, 1991) was implemented in stages by first exposing the faculty to the CAD system purchased for the department, then hiring an instructor to facilitate the integration of CAD into design/production courses.

Studies by Belleau and Bourgeois (1991) and Kallal and Fraser (1984) demonstrate the need for clothing and textile departments to keep curricula updated to include the newest CAD technology. However, the cost of CAD systems is an obstacle for most units and is compounded by the lack of instructors proficient in the use of CAD and by not understanding how to integrate CAD into the design curricula.

Design programs must become modernized to keep pace with the industry. Apparel design students must be prepared to use CAD attitudinally and intellectually in the apparel industry. Studies (Orzada, 1990; Belleau & Bourgeois, 1991; Belleau, Orzada, & Wozniak, 1992) have found that when students are exposed to CAD in their design courses they develop a positive attitude toward the use of CAD for designing in the industry. A positive attitude can only be fostered through the introduction and use of computers in the design curriculum.

Therefore, this research will investigate methods for CAD use in a design course, student attitudes toward CAD, and how colleges and universities across the country have used CAD.

DEFINITIONS

The following definitions are given to help clarify their meaning in the research:

Computer aided design (CAD) - software that assists with pattern development and marker making (Glock & Kunz, 1990, p. 514).

Computer hardware - components that comprise a CAD system, such as digitizer, workstation and plotter.

Computer software - the computer program that has been written and developed with different functions of CAD with executable options.

Computer Integrated Manufacturing (CIM) - the ability to transfer data between various workstations or systems in both the manufacturing and business environment (Computer power:, 1989, p. 34).

Efficiency - occurs when a certain output is obtained with a minimum of input (Chase & Aquilano, 1992, p. 28).

Grading (pattern grading) - the process of increasing or decreasing the dimensions of a pattern at specific points according to certain grade rules of proportional change (Glock & Kunz, 1990, p. 520).

Marker - diagram or arrangement of the pattern pieces for style(s) and size(s) that are to be cut at one time (Glock & Kunz, 1990, p. 519).

Marker making - process of arranging pattern pieces in the most economical manner for cutting (Glock & Kunz, 1990, p. 519).

Operational Definition

Efficiency - involves the time component, as measured by the graduate students in a CAD course, and the steps in process, as determined by the researcher and instructor of the CAD course, that are required to complete assignments on the computer.

Chapter II

REVIEW OF LITERATURE

CAD technology has rapidly increased in use in the apparel industry since the 1960s when CAD was first introduced for pattern grading. CAD is used as a tool in the pre-production departments to speed up many of the design and pre-assembly processes. Colleges and universities are looking closely at ways to implement CAD into the design curriculum so that students will have a working knowledge of how this technology is used in the apparel industry. Major areas of related literature that were reviewed for this study are history of CAD, CAD in the apparel industry, industry strategies related to CAD, attitudes of operators toward using CAD, and CAD usage in education.

History of Computer Aided Design - Early Development

Computer graphics is basic to CAD. This technique originated at the Massachusetts Institute of Technology (MIT) in 1950 when the first computer-driven display, linked to a Whirlwind 1 computer, was used to generate simple pictures. In 1963, computer graphics were significantly improved when a system called SKETCHPAD was demonstrated at the Lincoln Laboratory of MIT. This system enabled the user to draw pictures on the screen and to use a light pen to manipulate the picture. The cathode ray tube (i.e., screen) had the potential to be a designer's electronic drawing board. With the push of a button, graphic operations such as scaling, translation, rotation, animation, and simulation could be performed automatically (Besant & Lui, 1986).

The aircraft and automotive industries were the first to adopt the computer based design system that was too costly for other industries. The lack of appropriate graphics and application software for the computer-based design system prevented the extensive use of computer graphics in the engineering industry; however, new and improved computer hardware and software were quickly developed allowing expansion of the technology in engineering. CAD systems were first used as automated drafting stations to develop engineering drawings which could be printed on computer-controlled plotters. Systems were further developed that had analytical capabilities, that had the ability to do kinematic analysis, and that included a testing technique to perform model analysis on structures (Besant & Lui, 1986).

Development of CAD in the Apparel Industry

The development of the CAD system in the automotive and aircraft industries soon generated interest in the apparel industry (Considine, 1968; Ford, 1979). This new technology was first introduced in the apparel industry in the late 1960s by large apparel manufacturers who used the technology to write computer programs that allowed them to digitize pattern pieces into the computer system, grade the pattern into a range of sizes, and then have the computer plot the pattern pieces for all the required sizes. During this era, computers were large and very expensive and required expensive service contracts; so, utilization was limited by cost (Wilhelm, 1983).

The first successful CAD system for the apparel industry was developed and manufactured by Camsco in 1972 (Wilhelm, 1983). Also in 1972, White Stag became one of the first apparel manufacturing companies to invest in a computerized marking and grading system with the purchase of the Marcon system (Kosh, 1987).

Hughes of Hughes Aircraft Company entered the CAD market for the apparel industry a few years later with the Autographics package. The systems used Hewlett Packard

2100 minicomputers, with apparel related hardware and software features. Market projections by Camsco and Hughes stated that the apparel industry would hit a saturation point with fewer than 100 systems. The installation of CAD systems in the apparel, footwear, and related sewing industries worldwide, for the year 1983 was more than 1,100 systems (Wilhelm, 1983).

Three major computerized systems in pattern making, grading, and marker making emerged in 1983. They were Camsco's Markamatic and React system, Gerber's AM-5 system, and Lectra's Modular system. Also, in 1983 Roe Van Fossen of Wolverine Worldwide started developing a 3-D system to design shoes. Van Fossen envisioned designing a shoe in 3-D with the computer and, from the design process, produce all the data necessary to automate the production of the shoe. The success of Van Fossen's system in the shoe industry was instrumental in the apparel industry's adoption of this type CAD system in the workroom (Tray, 1987). By 1987, one third of apparel companies were using grading and marking systems (Kosh, 1987).

The 1982 Manufacturing Clothier's Microcomputer Workshop unveiled a system for full color fashion sketching displayed on the screen. However, this full color system received minimal response (Disher, 1985). At the 1985 International Clothing Machine Fair (IMB) CAD equipment reflected a few small improvements from the original sketching system offered in 1982. Three major CAD system suppliers, Gerber, Investronica and Microdynamics, promoted CAD sketching systems as the newest idea for the industry. These CAD sketching systems would generate much interest among those attending Clo-Tech with the booths of Gerber, Investronica, and Microdynamics attracting large crowds to view these systems. Although improvements had been made since 1982 the companies all stated that more research and development was necessary before the sketching system could be interfaced with PDS and marker making (Disher, 1985).

Further improvements were made to CAD systems in the 1980s to facilitate apparel manufacturing's preproduction process. These improvements focused on fashion sketching and pattern making, an area that had been virtually ignored. For instance, Camsco introduced a Pattern Design System (PDS) in 1980 that was developed specifically for pattern manipulation by automation (Fader, 1989). Later, Microdynamics developed a system that allowed a design to be created on the screen and that automatically created the patterns necessary to produce the sample (Wilhelm, 1984).

CAD vendors and suppliers continued to develop CAD equipment in the 1990s for the industry concept of Computer Integrated Manufacturing (CIM). These CAD developers proclaimed the nineties as the decade of "building bridges between islands of technology" (DeWitt, 1991, p. 34). Technology transfer reaped benefits for the apparel manufacturer because of the ease of transferring data from the supplier, to the manufacturer, to the retailer so that apparel products could be produced quickly for sale to the consumer (DeWitt, 1991).

A survey conducted by the National Knitwear and Sportswear Association (NKSA) was used to identify trends in CAD use in preparation for the CAD EXPO held August 17-19, 1993 in New York City. The NKSA found that, as of 1993, 51% of the apparel and textile designers surveyed used CAD in their work ("Number of", 1993). The survey also found that, of the designers not currently using CAD systems, 89% anticipated using them in the future and also believed that CAD would increase their productivity on the job. Results of the survey illustrate the importance of CAD usage in the design of apparel and textiles ("Number of", 1993).

Computerized Grading and Marker Making.

The early success of CAD systems in the apparel industry was mainly in the pattern grading and marker making functions (Wilhelm, 1985). Walter Wilhelm (1984) stated that the three principal reasons for the early emphasis in the area of grading and marker making were: (a) the procedures are uniform therefore, they are easier to systematize, (b) the procedures provided greater cost savings and faster turnaround on new styles that could be justified to the production director, and (c) pattern data could be captured for automation of the cutting and sewing operations.

The manual process of increasing or decreasing the sample pattern (i.e., pattern grading) to create the range of different sizes needed for production was simplified by digitizing the pattern into the computer's memory and then using x,y coordinates to increase or decrease all the significant points on the sloper to make the different sizes. Pattern quality was improved, and the time to produce the patterns was greatly reduced (Irish, 1968).

The marker making function using CAD technology also improved the pre-production phase of apparel manufacturing. The previous method of manually manipulating pattern pieces for multiple sizes in a spread was a time consuming process. Computerized marker making provided the following benefits: greater accuracy, pattern alignment on the grain within the marker, quick adjustment of existing markers in memory if adjustments of pattern pieces or marker width were required, and virtual elimination of errors such as marking incorrect size pattern pieces and misplacing notch marks and drill holes (Staples, 1980-1981).

The early work in computer pattern grading facilitated the entry of the less expensive minicomputer into the design workroom which eventually led to experimenting with the minicomputer for marker making. During this developmental period (i.e. early 1970s) Ron Martell, founder of Camsco, and Louis Wohlmuth, founder of Autographics, created what was considered "truly effective and practical packages" for pattern grading using the minicomputer (Wilhelm, 1983, p.156). These men are credited with establishing CAD technology for the sewn goods industry (Wilhelm, 1983).

Minimal changes in CAD systems occurred over the next 10 to 15 years. Computer hardware improved (e.g., processing speed, more memory, lower prices) for CAD system use, and software continued to improve as the shortcomings of the original programs were replaced (Wilhelm, 1983). Computer grading and marking technology did not change substantially until 1984 and 1985 when Lectra began working on automatic marking routines (Wilhelm, 1985). According to Wilhelm, advances in computer technology of more powerful hardware and more versatile software influenced the change in computer grading and marker making technology. Lectra attempted to develop a software program that would save time and labor in the marker making process by automatically placing pattern pieces within the marker. This automation displayed the whole marker on the screen so the computer operator could conveniently move pattern pieces within the marker to maximize efficient use of fabric and decrease labor cost by reducing the amount of time previously spent manipulating full scale markers. These benefits, time and money savings, illustrate how CAD could save on the overall cost and quality of a garment ("Hi-tech at", 1986; Wilhelm, 1985).

Microdynamics developed an Apparel Design System in 1985. This system used a microprocessor which could be user maintained, eliminating the need for an expensive service contract. The popularity of computerized grading and marking systems was revealed in a study conducted by the Bobbin Consulting Group in 1987. The results indicated that "approximately one-third of apparel companies in the U.S. have computerized grading and marking systems. With the systems' prices continuing to go down, this number should continue to increase" (Kosh, 1987, p. 52). The large apparel manufacturing companies confirmed that the reasons for using the early grading and marking systems were fabric savings, manufacturing flexibility, and quality control.

Computerized Pattern Design

As previously mentioned, CAMSCO was the first to introduce a PDS system for patterns. In the early 1980s PDS was introduced by CAMSCO for the Markamatic 5000, a minicomputer CAD system developed to automate pattern design. PDS offers the designer the power of the computer to produce or rework designs and fabrications and to maintain a library of those elements. PDS also increases the speed of the design process (Fader, 1989).

PDS systems eliminate some of the inaccuracies associated with the manual flat pattern process. PDS electronically stores pattern pieces and gives the patternmaker precise and accurate blocks from which to design. The size and dimensions of the pattern stay the same until the CAD operator alters it. This precision of block patterns results in better quality garments because of measurement accuracy (Lee & Steer, 1991).

In the late 1980s, PDS programs were upgraded to increase their power and efficiency. In the 1990s, research continues in the development of PDS. The use of PDS as a computer tool in flat pattern work has prompted several CAD manufacturers to develop new CAD packages for the apparel industry. The common element of these CAD packages is the electronic pattern-making table (Staples, 1992).

These electronic drafting/pattern-making tables were featured at the 1992 CAD Expo held in New York City. The table allows patterns to be created using pattern design tools (i.e., rulers, french curves) and functions on the same principle as a digitizer where the pattern image is stored in the computer's memory. Once the image is stored in the computer's memory, it can be retrieved for further manipulation and changes on the screen.

Jim Hurley of Investronica stated, "The magnetic table has really become a popular tool for pattern making,... It's a good way to convert designers to use computers" ("CAD/CAM systems", 1992, p. 33).

Computer Graphics

Computer graphics technology has evolved and changed along with the other components of a CAD system. The display of images on the screen has changed from black and white 2D rendering to the capability of using thousands of colors and 3D modeling. Frank Hughes (1984), at The Eleventh Annual International Apparel Research Conference, indicated that Gerber Garment Technology, Inc. was working on the development of four modular graphics capabilities, ranging from computer-rendered 3-D figures to shading and high resolution sketching. These developments were viewed as being necessary to make the CAD system a more effective tool for use by the designer.

Three types of design systems became available in 1988: the 2-D design illustration/styling system, the 2-D illustration/styling systems that simulated 3-D functions, and the actual 3-D design system (Waddell, 1988). Although improvements were made in perception, the developments of these new design systems did not eliminate the discrepancy between the colors that an operator saw on the computer screen and what was printed on paper. Some companies have attempted to solve this problem in order to receive the full benefits of their CAD system (Kosh, 1989).

Freedman (1990) suggested that the trend in computer graphics research was to make the technology more user friendly so designers could easily create a design on the screen with 2-1/2-D draping. The justification for this development of draping on the screen was to reduce the high cost of the initial prototypes of the design through manual procedures. This function has not achieved the same success as the 2D functions of grading, marker making, and pattern making because apparel systems need hang and drape functions written into the program, these algorithms are some of the most difficult for the computer programmer to write (Waddell, 1988).

The CAD equipment at the 1991 Bobbin Show showed improvements in computer graphics and printing capabilities (Cedrone, 1991). Both Lectra and Microdynamics featured improvements in the graphics capabilities of their systems. Lectra improved fabric draping functions and an electronic pen to use in sketching that offers over 16 million colors. Microdynamics focused on software development that could be interfaced with the standardized graphic format, so designs created with MicroDesign could be transferred to desktop publishing software and then used to create ads for catalogs.

Many CAD vendors have attempted to improve their CAD graphics systems. For instance, Lectra's latest innovation in the graphics area in 1992 was improvement in speed, quality, and additional color choices, up to 16 million (Slom, 1992). Not only were graphics improved through resolution but also the speed of image regeneration was improved to a level where images could be changed instantly on the screen. By using sophisticated printers, the image on the screen can produce a photographic quality output that could actually be used by salespeople to sell garments to their customers.

A new use for CAD graphics in the apparel industry is in the field of electronic graphics interchange (EGI) (Aldrich, 1989). EGI allows textile designers and apparel designers to send CAD produced graphics electronically to each other and to alter the design after it has been transmitted. Wilson (1989) identified the benefits of EGI as cost reductions in the areas of sampling and product development, as well as, "reduced product development cycle times, improved customer service, improved creativity, and reduced risk" (p. 60). This capability is particularly effective in situations where the designers are geographically removed from the production facility.

The Textile Apparel Linkage Council (TALC) was begun in May 1985 when representatives from the textile and apparel industry met to discuss how communication formats and linkages could be established within the textile, apparel, and retail industries (Santora, 1986). TALC's focus in 1988 was on EGI, an area in need of standardization so that graphic images could be transmitted between the different industries to decrease the lead time for design. TALC also recommended improvements to EGI that would allow pictures to be modified after they were transferred from one computer source to another (Aldrich, 1989).

Future developments

The apparel industry is constantly looking for more efficient methods of producing garments which includes the design process, cutting, sewing, finishing, and shipping. The trade literature reveals that, in the future, CAD technology is the tool most companies will use in the design stages of apparel production ("Number of", 1993).

The systems developed by CAD/CAM companies have grown with products being offered to facilitate processes from garment design to computerized spreading. These innovations across manufacturing processes have increased the need for common interfaces in each piece of equipment. Common interfaces allow companies to upgrade systems or buy different vendors' products and use them together in the design and pre-production processes (Adams, 1988).

A survey of CAD companies conducted by the National Knitwear and Sportswear Association indicated that the use of CAD in the apparel industry would increase by 150% between 1991 and 1997 (Maycumber, 1992). The survey revealed that suppliers of CAD felt that, as of 1991, approximately 30% of all designers and manufacturers were using CAD, but by 1997 that figure would grow to 75%. The 30% usage figure was an average of the different percentages given by the CAD companies. The actual percentage ranged between 15% to 85%. All CAD manufacturers agreed that CAD was a growing technology, and sales of CAD equipment would increase in the coming year (Maycumber, 1992).

This increased investment in CAD technology by apparel manufacturers will create a need for pre-production department employees (e.g., designers, patternmakers) to be knowledgeable about computers and their use in the apparel industry (DeWitt, 1991). Individuals desiring to work in any of the pre-production departments will find they are more employable if they have a working knowledge of CAD.

CAD companies are working closely with the apparel industry to develop hardware and software that will improve the pre-production process (Staples, 1992). The technology is designed to combine traditional pattern making techniques with CAD so that reluctant designers will accept CAD as a tool to be used in the design process. Also under development is the software which will allow transformation of 3D graphics design of apparel to 2D pattern development with minimal pattern making work required by the designer/patternmaker. Southwestern Louisiana's A-/CIM Center is working on this technology, as well as developing an artificial intelligence system for pattern making, proving that this function can actually be represented on the computer with the same expertise of a patternmaker (DeWitt, 1992). Other advancements in CAD technology for the textile and apparel industry were presented at the 1992 CAD Expo held in New York City. For example, one vendor presented a CAD system that is capable of printing, in color, a full size paper pattern that could be constructed into a useable product sample. This same process is being further developed to produce the pattern on fabric, rather than paper, a development that is sure to facilitate garment production ("CAD/CAM systems", 1992).

Industry Strategies Related to CAD

As import growth has escalated, apparel manufacturers have attempted to identify strategies to improve their competitiveness. Technology has accelerated the design process, improved the manufacturing process, and reduced the lead time between the apparel manufacturer and the retailer. The time for development of new styles and patterns for these styles has been reduced with the use of CAD. The use of CAD in the design process now provides data that is used for Computer Integrated Manufacturing (CIM). CAD and CIM are integral components in the objectives of Quick Response (QR) (Cassill & Kincade, 1990; Kincade, Cassill, & Williamson, 1993).

Quick Response (QR)

Clarification and implementation of the QR concept for the apparel industry was addressed at a research conference in 1985 ("10 years", 1992). QR encourages textile manufacturers, apparel manufacturers, trim suppliers, and retailers to work together through electronic data interchange to increase production efficiency, to improve product quality, and to speed delivery of the products (Glock & Kunz, 1990). The interest, support, and involvement in QR was highlighted with a large attendance of apparel pipeline industries at QR '89 ("10 years", 1992).

QR focuses on partnerships in the soft goods chain that provide improved information flow, and flexible technology. This technology is used to reduce inventory within the soft goods chain (Cassill & Kincade 1990). According to Wilson (1989), CAD/CAM systems have greatly contributed to the evolution of this QR focus.

Apparel Industry Magazine surveyed small, medium, and large companies involved in Quick Response to determine the most frequently purchased technology ("Big Firms", 1992). The most frequently purchased technology for product preparation was CAD. Of the small companies, the 1991 survey showed 8.1% had purchased CAD, 18.4% of the medium companies had purchased CAD, and 29% of the large companies had purchased CAD equipment.

The investment criteria considered by the small size companies when purchasing CAD equipment was superior product, price, and service, in this order. The medium size companies looked at price, superior product, and compatibility; the large size companies looked at compatibility, service, and superior product ("Big Firms", 1992).

The need for CAD systems to be compatible with other apparel equipment, such as the cutting systems, is important in achieving the benefits of QR (Black, 1992). The other criteria, price, superior product, and service, are key factors in the purchase of CAD equipment (Grudier, 1992; Grudier, 1993).

Computer Integrated Manufacturing (CIM)

The 1988 Bobbin Show displayed a variety of computer systems. The CAD/CAM companies demonstrated new developments in equipment available for the apparel industry. Some companies focused on CAD/CAM equipment that could be used in the newest industry concept of Computer Integrated Manufacturing (CIM) (Adams, 1988). The purpose of CIM is to integrate all functions within the apparel manufacturing process from the business end to the production end. The concept of CIM is important to the success of QR. The goal of QR can be realized only through the use and availability of data concerning orders, (e.g. customer orders, piece goods orders, trim orders, etc.), as well as the ability to track garments through the preproduction and production processes.

Automation of manufacturing processes through CIM moved closer to reality with the formation of the Computer Integrated Manufacturing/Linkage Council (CIM/LINC) ("10 years", 1992). The mission of this council was "To facilitate the implementation of CIM in the apparel industry through the establishment of voluntary standards for communication among merchandising/manufacturing related functions" (Colgate & Smarr, 1988, p. 86). The CIM/LINC is working to have common standards for data communications (Adams, 1988).

CAD is a key component of CIM and must be integrated into the computer network for CIM to function properly. CAD generated data is being used in CIM programs to improve many pre-production and production processes. Some of these programs manage the cutting operation and the costing of garments, and they can generate general specification sheets for time consuming manual processes (DeWitt, 1991).

CAD systems are constantly changing to meet the demands of the apparel industry. They are becoming more user friendly and less intimidating to the designer (Staples, 1992). Systems that can be integrated with other computer equipment used in apparel manufacturing are being developed so that CIM can become more of a reality in the apparel industry (DeWitt, 1991). This integration is also necessary for the industry's push toward QR ("10 Years", 1992).

Computer Usage in Education

The evolution and growing use of computers and CAD in the industry has generated interest in the use of computers and CAD in the education system. Administrators in both secondary and higher education systems have recognized the importance of incorporating computer technology in curricula. Madsen and Sebastiani (1987) stated that microcomputers were affecting educational procedures and would certainly influence the future of education. Mehlhoff and Sisler (1989) reported that the use of computers by students and educators was essential to what they called the "Information Age" (p. 300).

Offerjost and Terry (1987) also affirmed the importance of computers in education and suggested that if students are not exposed to computers they will receive an incomplete education. The inevitable future of computer applications in all occupational areas has prompted researchers to investigate people's attitudes toward using the computer. According to Mehlhoff and Sisler (1989), the effective use of computers in the classroom can only take place if educators have a positive attitude towards computers. Madsen and Sebastiani (1987) alluded to studies regarding the change in students' and teachers' attitudes toward computers after using the computer.

Attitudes toward computers

Computer use has become more prevalent over the past several years with the average person having daily contact with a computer either by direct use in the office, through the use of calculators, automatic banking machines, or other computerized items. This increased use of computers has created a growing interest in the study of how humans interact with computers and what their attitudes are toward computers (Popovich, Hyde, Zakrajsek, & Blumer, 1987).

Attitudes are important determinants of how well an individual adapts to new technology (Madsen & Sebastiani, 1987). The increased use of computers and computer technology in the work place has therefore, created a need for employers to examine the attitudes toward computers of future employees and employees already in the work force to determine whether an employee can be productive using computers. A positive attitude toward computers by employees can signify a willingness to learn and use computers; whereas, a negative attitude can affect the productivity of the individual if given a job where a computer is utilized (Machin, 1991).

Faculty and student attitudes toward computers

The use of computers in many aspects of higher education led Mehlhoff and Sisler (1989) to investigate the attitudes of home economics faculty toward computers. Their study was based on "the theory of innovation and adoption of change" as well as the "importance of attitudes in the learning process" (p. 300). Mehlhoff and Sisler (1989) surveyed 719 faculty who were members of the Association of Administrators of Home Economics in State Universities and Land Grant Colleges and the National Council of Administrators of Home Economics. They found that home economics faculty, in general, had positive attitudes toward computers as educational tools and that the more experience faculty had working with computers, the more positive were their attitudes. Other findings in this study indicated that these faculty wanted to increase their use of the computer in the classroom and for word processing through increased knowledge of computers.

However, student attitudes toward computers are also important since the technology is being used in the classroom. Morrison (1983) studied student attitudes toward computers and concluded that the students were concerned that computers could have a dehumanizing effect and could somehow control their lives. He also concluded that positive acceptance of computers was still not apparent and more public education was needed for people to understand and learn how to use computers.

Popovich, et al. (1987) surveyed 351 undergraduate students and found that, in general, "females are less positive than males in their reaction to computers" (p. 268). However, females tended to have more positive attitudes toward certain new technologies than males. This finding indicates that the reaction by individuals to computers can not always be predicted according to the sex of the user. Another finding from the Popovich et al. (1987) study was that attitudes were positively influenced by prior use of computers.

Orzada (1990) investigated the attitudes of students toward a tutorial developed for use in a flat pattern class. Students were first introduced to flat pattern techniques in the classroom through manual manipulation for problem solving. The same problems were then resolved on the CAD system. The effectiveness of the tutorial was evaluated through comparison of grades received for the manual flat pattern problems and the computer problems. In general, grades were similar for problems executed manually and by computer. Orzada also administered a pretest and posttest questionnaire to determine the students' "attitudes toward the course, importance of the subject matter, the computer as an instructional tool, attitude toward computers, usage of computer technology in the apparel industry, and content of the tutorial" (p. 44). Her questionnaire included items from an attitude scale developed by Morrison (1983) and the Attitude Toward Computer Usage Scale (ATCUS) developed by Popovich, et al. (1987).

Orzada (1990) found that the students had positive attitudes toward computers and the use of CAD in the course, which suggested that students in apparel design programs are realizing the importance of learning CAD. She summarized by stating, "Students realize that the increasing use of computer technology in the apparel industry will be essential in the future, and were eager to gain computer pattern-making experience through the CAD tutorial" (p. 62).

Apparel designers attitudes toward computers and CAD.

Fraser (1985a, 1985b) examined the attitudes of designers, patternmakers, and production managers in the apparel industry who were using computerized production equipment. The areas addressed in the questionnaire were general computer attributes, production factors, physical factors, and job related factors. The results of the study indicated that patternmakers and production managers were beginning to accept CAD as part of the total production process. The slow acceptance of computer production aids by the U.S. apparel industry appeared to lie wholly with designers. "Almost half of the designers in the study viewed CAD unfavorably when it came to actually using it as a designing tool themselves" (p. 44). Fraser (1985a, 1985b) concluded that the attitudes of the designers toward CAD could be improved through the inclusion of CAD in the educational process. Exposing students to computers, particularly CAD, should encourage a more positive attitude toward computer technology as a design tool and ultimately help the designer to accept and use CAD in the work place.

Hagenbrock (1990) conducted telephone interviews of 73 CAD technicians who were currently using CAD systems in their work and who had also previously performed their work using manual methods. She examined three aspects of the technicians attitudes toward CAD. These attitudes were: (a) "relative advantage - the degree to which the innovation was perceived as better than the idea it superseded" (p. 6), (b) "compatibility - the degree to which the innovation was perceived as being consistent with the existing values and past experiences of the CAD system users" (p. 4), and (c) "complexity - the degree to which the innovation was perceived as difficult to understand and use" (p. 4). Relative advantage pertained to the involvement of the CAD operator in the decision to implement CAD into the company. Compatibility was based on the number of years the CAD operator had used non-computer methods to do their job before using CAD. Complexity related to the number of years the CAD operator had been using the CAD system.

Hagenbrock (1990) concluded that CAD users who had previously used manual methods to perform their jobs generally had a favorable attitude toward the use and implementation of CAD. She found that the technician's involvement in the decision to use CAD, their years of manual experience, and their years of CAD experience did not significantly affect their attitude toward CAD.

Machin (1991), a CAD expert at the Royal College of Art in London, emphasized the need for designers to be exposed to computer applications in the apparel industry. She acknowledged the difficulties faced by colleges, universities, and industry in acquiring CAD equipment - equipment cost, personnel training, and the attitudes of the personnel that are currently working for the manufacturer. According to Machin (1991), it is the responsibility of those involved with the textile and apparel industry to promote the use of CAD through active involvement with apparel design programs at colleges and universities. She also felt that it was important for these companies to promote a positive attitude toward CAD through education and training of employees affected by the use of CAD in the work place.

Bushell and Rabolt (1992) conducted a telephone survey to study computer anxiety and attitudes toward the use of CAD. The sample included apparel professionals who were members of a local fashion trade association. The result showed that the more experience and training the individual had using computers, the more positive was their attitude toward CAD. Bushell and Rabolt concluded that the "awareness of attitudes toward the use of computer-aided design and computer anxiety levels will assist ... in the future development of curricula for future apparel professionals" (p. 64).

Summary - attitudes

The previous studies have documented the significance of attitudes of faculty, students, and designers toward computers or CAD and the effects of attitudes on using this technology in the classroom and at work. The necessity for faculty to have positive attitudes toward CAD for classroom use is imperative if the students are to learn that CAD is a tool available for the apparel designer to create sketches, patterns, and markers. However, students must also have a positive attitude toward computer use in the classroom if learning is to be successful.

CAD in the Apparel Design Curriculum

The introduction of pattern grading and marker making technology created challenges for the apparel industry. The lack of qualified personnel to use CAD systems and also the fear of automation by personnel already employed in the pattern department curtailed the use of this equipment by the apparel manufacturer. However, this restrictive use of the pattern grading and marker making technology lasted only a short time as the apparel industry started considering new ways to compete with imports that were threatening the domestic apparel market.

Apparel manufacturers and CAD companies recognized graduates of apparel design programs as a source for potential CAD operators (DeWitt, 1991). Moreover, apparel design programs recognized the importance of developing linkages with all levels of the textiles and apparel industry (Kunz, Lewis, & Coffin, 1992). This influenced the creation of advisory boards to provide recommendations on the type of knowledge and training students needed in order to be more employable in the apparel industry ("Automation makes", 1984).

Faculty in college and university clothing and textiles departments understand the importance of student exposure to CAD in the classroom and in the design curricula. This exposure to CAD better prepares the students for employment as designers and pre-production workers in the apparel industry (Sheldon & Regan, 1990). Furthermore, CAD exposure promotes a more positive attitude toward automation in the industry (Caldwell & Workman, 1985). Clothing and textile programs began to expose students to CAD in the early 1980s by integrating CAD into the design curriculum (Van De Bogart & Knoll, 1990).

Fraser (1985a, 1985b) contends that, in the future, fashion design programs will introduce and use computer systems at all levels of the designer's education. Courses that are strategic to the designer's education and which may incorporate CAD are Principles of Color and Design, Apparel Construction, Flat Pattern, Designing Groups, Pattern Drafting, and Fashion Illustration (Sheldon, 1988). The need to introduce computers to students compels colleges and universities to incorporate CAD into their curricula. According to a study by Knoll (1989), most educators are already using computers in some way in their jobs and are eager to expose students to more industry computer applications whether it is in the area of design or fashion merchandising.

Difficulties of incorporating CAD into the curriculum

Three issues must be considered when incorporating CAD into the curriculum. The first is the amount of time required for instructors to learn CAD before they teach it in the classroom. The second issue is the lack of funds available to purchase the CAD hardware and software. Finally, a decision must be made regarding what to eliminate from the existing curricula so that CAD can be included (Van De Bogart & Knoll, 1990).

The lack of qualified faculty to teach CAD in the design curriculum is a problem that clothing and textiles departments must face in implementing CAD in the design curriculum (Koch, 1990). Venkataraman's (1992) study found that most designers felt that the training period to become proficient on a CAD system was 1 to 3 months but it should be noted that this time frame was probably based on the designer being exposed to the system at least 8 hours a day, 5 days a week. Not many faculty can afford to devote this amount of time to learning and acquiring the skills necessary to become proficient in the use of CAD because of other obligations within the department (such as teaching, research, and committee assignments) (Van De Bogart & Knoll, 1990).

The cost of most CAD systems (Lectra, Microdynamics, Gerber Garment Technology, Camsco, etc.) can severely affect the operating budget of most clothing and textiles departments (Huck & Hedrick, 1990). Even if a department is able to purchase a system, the cost of keeping it updated with the latest software and hardware can also be prohibitive.

Departments that have equipment and qualified personnel to teach CAD in the design curriculum also have the task of making it an integral part of the design curriculum (Belleau & Bourgeois, 1991; Van De Bogart & Knoll, 1990). The question then becomes what should be eliminated from existing courses so that CAD can be added. This decision is not easy since all material presented to students is considered important to their education and employability. Another obstacle that must be faced when integrating CAD into the design curriculum is the lack of instructional materials related to CAD. The instructor usually must develop his/her own materials or contact other instructors who have integrated CAD into the design curriculum for suggestions and ideas on what type of materials to use (Huck & Hedrick, 1990; Koch, 1990; Steinhaus, 1988).

The use of computers for assignments in clothing and textiles classes can be a time consuming and expensive job, but it can also be a rewarding undertaking (Grasso & Craig, 1988). Student exposure to CAD systems can no longer be ignored by any clothing and textiles department since the use of computers has become so important in today's society. Computers are being used extensively in just about every industry, so students must be exposed to their use so they can compete in a job market that demands some knowledge of computers as well as application of that knowledge.

Alternatives to costly computer systems

The high cost of CAD equipment used in the apparel industry is often prohibitive to educational institutions and has therefore, prompted the use of microcomputer and CAD software in many clothing and textiles departments (Sheldon & Regan, 1990). Microcomputers are more affordable than CAD systems for industry because the equipment and CAD software can be shared by other departments on campus (Koch, 1990; Racine, 1993). The size and cost of microcomputers enable the lab to be equipped with more workstations for student use, whereas the size and cost of industrial CAD equipment limit the number of workstations that can be purchased and made available for students.

The most popular software currently used for microcomputers is AutoCAD® (Dockery, 1989; Huck & Hedrick, 1990; Miller, 1990a; Steinhaus, 1988). This software is used in engineering, interior design, and in the clothing and textiles curricula (Steinhaus, 1988). Some educators in apparel design have developed supplemental programs to use with AutoCAD that have functions similar to the software used with industrial CAD systems. The more well known supplements that are available for purchase are ApparelCAD™, BetaCAD™, and PC Pattern©. Some clothing and textiles departments, however, use AutoCAD without these supplemental programs to teach the concepts of CAD (Miller, 1990a; Steinhaus, 1988).

The following descriptions summarize the features of ApparelCAD, BetaCAD, and PC Pattern:

> ApparelCAD™ features are presented as follows: complete set of slopers for misses', croquis figures for fashion illustration, dart manipulation commands, complete set of ready-to-use pattern symbols and labels, a special grading menu, drafting menus, self running lessons, a tablet template, many specialized macros that streamline functions, and an illustrated manual with step-by-step instructions (Miller, 1990b).
>
> BetaCAD™ features are presented as follows: professional results at a fraction of the cost of proprietary systems, extensive library of design components and accompanying patterns, extensive library of block patterns and pattern symbols, pattern grading and pattern marking with fabric efficiency utilization, supports 16 million colors, educational program, full documentation with slide transparencies, and 2 years/free updates (Promotional and sales literature from the developers of BetaCAD™).
>
> PC Pattern© features are presented as follows: allows you to handle the entire design process from sketching to pattern making, draft patterns and label the final product with the symbols from the library, grade patterns with ease and speed, make markers and calculate fabric yardage and efficiency, offers a sloper library which provides you with a complete line of all sizes of slopers, with grade rules to be used with the slopers, and offers product support through newsletters and educational materials (Promotional and sales literature from the developers of PC Pattern™).

All of these supplemental programs feature similar functions; therefore, it is difficult to recommend a specific program that would best supplement AutoCAD.

As previously indicated, the availability of CAD software for apparel functions is increasing. Instructional materials for this software is limited to instructions related to using the specific software. Textbooks and comprehensive instructional materials for CAD, however are limited. Therefore, instructors in clothing and textiles programs which use CAD have developed their own tutorials and instructional materials that are more specifically related to apparel design problems (Belleau & Bourgeois, 1991; & Belleau, Orzada, & Wozniak, 1992; Knoll, 1990; Koch, 1990; Miller, 1990a).

Steinhaus (1988) discussed the difficulty of teaching AutoCAD in an apparel design course when most of the materials available for use with AutoCAD related to engineering and architecture. As a result, she developed a tutorial to accelerate student learning and increase their confidence when using AutoCAD for apparel design. Huck and Hedrick (1990) developed a lab manual, AutoCAD® for Apparel Design, to supplement AutoCAD use in apparel design courses. She also found that good instructional material was not available for the apparel design field, and with the development of the lab manual, AutoCAD® for Apparel Design, the students quickly learned AutoCAD and how to apply it to CAD in the apparel design field. Sheldon (1990) taught a CAD course in which she used a design evolution assignment to increase student awareness of the time savings that could be realized with the use of CAD in the design process. The CAD course taught students about computer applications for fashion illustration, patternmaking, grading, and marker making.

Another means to help in the development of instructional material for course instruction is through CAD workshops sponsored by some of the larger schools that have CAD systems ("Automation Makes", 1984). These workshops are available for people in industry as well as education. The workshops enlighten faculty on current industry practices as well as provide an understanding of entry level skills students need for the job market. Some workshops are designed to help educators become more proficient with using CAD in the classroom. These workshops also provide a forum for educators to share ideas about implementing CAD in the classroom (Miller & DeJonge, 1987).

Summary

The literature documents how CAD technology has evolved in the apparel industry and the need for educators in the apparel field to be expeditious in integrating CAD in the design curricula. In order for students to be prepared for employment in the apparel industry, they must be familiar with CAD (i.e., operations and applications). The increased investment in CAD technology by apparel manufacturers has created a need for pre-production department employees (e.g., designers, patternmakers) to be knowledgeable about computers, design, patternmaking, and grading; therefore, individuals desiring to work in the pre-production areas can be more successful if they are familiar with CAD (Sheldon, 1988; Van De Bogart & Knoll, 1990).

The challenge in higher education is for the instructor to introduce CAD in a way that encourages student acceptance of the technology. A positive attitude by the instructor and students enhances their understanding and use of CAD (Huck & Hedrick, 1990; Steinhaus, 1988). The cost and availability of CAD equipment and software for apparel affect the effectiveness of integrating CAD into the design curriculum. For example, the high cost of industrial CAD systems limits the number of workstations that can be purchased for student use, whereas the cost of microcomputer CAD systems is affordable yet the functions may not be comparable to the functions used in the industry. This research will investigate the use of an industrial CAD system and the microcomputer system with CAD software in an apparel design class as well as student attitudes toward using CAD for design problems. In addition, the integration and use of CAD technology in apparel curricula at other colleges and universities will be examined.

Chapter III

STATEMENT OF THE PROBLEM

CAD has become one of the many new technologies used by the textile and apparel industries to implement the strategy of Quick Response (QR). CAD was introduced in the apparel industry in the 1960s and computerized pattern grading was the first function available for use by the industry (Wilhelm, 1983) . Additional CAD software was developed and used over the next twenty-eight years. This software included CAD applications for marker making, patternmaking, cutting, and design/illustration. Although this new technology increased, the industry lacked qualified personnel to operate the sophisticated systems.

Kallal and Fraser (1984) reported that larger apparel manufacturers were hiring designers with college degrees and concluded that four year programs needed to have CAD in the curriculum to better prepare students for employment in the apparel industry. Kallal and Fraser also suggested that incorporating CAD in the curriculum would improve the designer's attitude toward CAD as a design tool and their acceptance of CAD in the workroom.

The integration of CAD into the design curricula was also supported by Sheldon and Regan (1990) who recommended the use of microcomputers in the classroom for CAD instruction. Based on their experiences with CAD in the classroom, Sheldon and Regan suggested that the CAD skills learned from the use of microcomputers would transfer to industrial CAD equipment. Belleau and Bourgeois (1991) also confirmed the importance of exposing students to CAD technology in the classroom.

Apparel design students must be prepared to use CAD both attitudinally and intellectually in the apparel industry. A positive attitude can be fostered through the introduction and use of computers in the design curriculum. Studies (Orzada, 1990; Belleau & Bourgeois, 1991; Belleau, Orzada, & Wozniak, 1992) have shown that when students are exposed to CAD in their design courses, they develop a positive attitude toward the use of CAD for designing in the industry.

The Clothing and Textiles Department at Virginia Tech owns a Lectra industrial CAD system which has one workstation. The department also has access to the college's microcomputer CAD lab which has twelve workstations. Since its purchase in 1987, the Lectra system has been used mainly for grading and marker making in the pattern grading and draping courses. The Lectra system has been used to a lesser extent for actual pattern design in the classroom. The CAD lab is equipped with AutoCAD software and is frequently used in the interior design program. The Clothing and Textiles Department purchased five copies of ApparelCAD, a supplemental program used with AutoCAD, in the spring of 1990. However, no formalized system has been developed for integrating the equipment and software into the curricula offered in the department. Therefore, in the Fall of 1992 a graduate level course entitled "Current Topics in Clothing and Textiles - Computer Aided Design" (CT 6004) was offered to explore how the two CAD systems could be used effectively to promote student acceptance of CAD and knowledge of CAD applications.

CT 6004 was an elective course that focused on enhancing the student's knowledge of the current status of CAD applications in the apparel industry for product development, pattern design, and pre-assembly functions. This course provided classroom and laboratory instruction in the use of the AutoCAD/ApparelCAD system and the Lectra system for pattern design. The specific objectives of the course were to enable students: (a) to explain CAD applications in product development, pattern design, and pre-assembly processes, (b) to use AutoCAD as a tool for pattern alterations, pattern design, grading, and marker making, and (c) to use the Lectra system as a tool for pattern alterations, pattern design, grading, and marker making. This course provided an opportunity to investigate which system could be best used for pattern design and manipulation, and was therefore an integral part of this study. Awareness of how other programs in the same discipline have used the technology will facilitate implementation of CAD in this department and others who need to know. Another focus of this study pertained to CAD use in clothing and textiles programs at other colleges and universities in the U.S..

Purpose

The purposes of this study were (a) to determine how to efficiently use the CAD systems that are accessible to the Clothing and Textiles Department at Virginia Tech for the apparel design curriculum, (b) to determine students' attitudes towards using CAD, and (c) to investigate the current use of CAD at other universities with apparel design programs.

Objectives and Rationale

The objectives of this study were:

Objective I. To investigate the attitudes of apparel design graduate students toward using CAD technology in the classroom.

Exposing students to computers, particularly CAD, should encourage a more positive attitude toward computer technology as a design tool and ultimately help the designer to accept and use CAD in the work place. Therefore, a measure of student attitudes before using the CAD systems in CT 6004 was administered as a pretest to determine their acceptance and use of CAD. The rationale for Objective I was to determine the attitudes of the apparel design graduate students taking CT 6004 toward CAD before being exposed to AutoCAD/ApparelCAD and the Lectra system in the classroom.

<u>Objective II.</u> To compare the efficiency of the AutoCAD/ApparelCAD system to the efficiency of the Lectra system as a tool to complete assignments in CT 6004.

As clothing and textiles programs contend with budget problems and the need to remain current in the use of CAD for apparel industry applications, the type of system to purchase becomes an issue. The Lectra system is relatively expensive (approximately $150,000), takes up more floor space and is limited by the number of workstations that can be used with the system. Microcomputers, however, are more affordable but are not used as extensively in the apparel industry. Yet, the importance of giving students experience with CAD would seem more efficient on the microcomputer; therefore, this study investigated the efficiency of the one Lectra workstation and the five AutoCAD/ApparelCAD microcomputer workstations for the assignments in CT 6004.

<u>Objective III</u>. To compare apparel design graduate students' preference toward using the AutoCAD/ApparelCAD system versus the Lectra system.

The use of both CAD systems was incorporated into CT 6004. The Lectra system was developed for specific use in the apparel industry while AutoCAD/ApparelCAD has been modified for use as an apparel CAD system. The two CAD systems can be used to achieve the same end but the process that is used to achieve these results are different, therefore, this study presumed that students would develop a preference for one of the two CAD systems they had used to complete the assignments in CT 6004.

<u>Objective IV.</u> To investigate the current use of CAD in the design curriculum at other colleges and universities.

In recent years colleges and universities with clothing and textiles programs have begun to use CAD as a teaching tool; however, no research to date documents what types of systems are used and how they are used. An understanding of how other clothing and textiles programs are using CAD and what types of software programs are being used, can assist in decision making regarding how CAD can be implemented and integrated into design courses.

Assumptions

1. Students in CT 6004 are representative of other college students in similar programs in the United States.
2. The respondents who completed the Educational CAD Use Questionnaire were knowledgeable of the implementation and use of CAD in their departments' program.

Limitations

The limitations of this study were:

1. The small enrollment in CT 6004 which was used as the sample, 3 students.
2. This study compared only two CAD systems of the several that are available on the market. They are the Lectra system and AutoCAD/ApparelCAD. The software used on the Lectra system and the ApparelCAD software were not the most current available.
3. The Lectra system had one workstation.
4. The instructor taught CT 6004 Current Topics in Clothing and Textiles for the first time.

5. Students received instructions on both CAD systems in this class rather than the usage of one CAD system each semester. Thus, students may not have had the time to become proficient with either system.

Contextual Framework

The evaluation of curricula in education is multifaceted but is dependent on the type of information desired. Needs assessment has often been used in education to identify problems in the school system and then to determine how to solve these problems through identification of resources and goals. This study used the needs assessment concept to determine how the Clothing and Textiles Department could efficiently use two CAD systems in its apparel design curriculum. CAD technology use has increased in the apparel industry over the last thirty years, creating a challenge for the industry to hire qualified personnel to operate these sophisticated systems. Colleges and universities with clothing and textiles programs and CAD systems can prepare students for these positions in the industry by providing training on the CAD systems.

Stolovitch (1978) defines need as "a gap between some ideal condition and an actually existing one" (p. 26). The ideal condition that is needed is to train students on CAD equipment that is the most current and is used in industry and provide each student access to a workstation. What actually existed for the Clothing and Textiles Department at Virginia Tech are limited number of workstations, limited faculty expertise, limited knowledge of how to effectively and efficiently use the available CAD equipment, and some outdated CAD equipment. The ultimate need then is to efficiently integrate the CAD systems available for use at Virginia Tech into the design curriculum so that students are prepared for employment in the apparel industry.

Mosrie (1980), discussed needs assessment and how allocating resources to resolve problems can ensure that a "sense of accomplishment and success is established in the school climate.." (p. 65). This concept fits with the purpose of this research which was to identify how resources, in the form of two CAD systems, could be used to enhance students' academic success and employability.

Trimby (1979) compared four needs assessment models: Kaufman's "Needs Assessment," Coffing's "Client Need Assessment," Lee's "Needs-Assessment," and Harless' "Front-End Analysis." These models were very similar in their intended outcomes but differed in the terminology which identified the sample. Kaufman's model emphasized that data collected for the needs assessment must come from the learners, the educators, and the community. Coffing's model relied on information from clients (i.e. students, parents, teachers, future employers of present students, etc.), while Lee collected data from students, staff, public served by the system, experts in the field, and authorities on the requirements of the future. Harless' model, which focuses more on business and industry but can be used for education applications, collected data from managers, supervisors, and training personnel (Trimby, 1979).

Trimby's (1979) matrix which compared the four needs assessment models influenced the decision to select Kaufman's model to guide this research. The operation of this study has an educational foundation and involves learners, educators, and the community in the assessment process. It emphasizes problem solving rather than decision making, which was the case for the other models (Trimby, 1979). Kaufman's model involves identifying and prioritizing gaps in the educational process, and then uses the available resources to close those gaps. The significance of these steps is the use of available resources rather than the process of acquiring resources to fulfill the needs of the circumstance.

Kaufman's needs assessment used a systems approach that consisted of 6 steps (Kaufman & English, 1979). These steps as they apply to this study are as follows:

1. Identify problems based upon needs. The problem identified in the review of literature was the need to incorporate CAD into the apparel design curriculum so that students are exposed to the technology of CAD.

2. Determine solution requirements and identify solution alternatives. The solutions used by others, as found in the review of literature, indicated that schools have approached the problem in different ways. These approaches were (a) to purchase CAD systems from the major suppliers in the apparel manufacturing industry, (b) to visit nearby apparel manufacturers that had CAD systems that agreed to let students use the system, and (c) to use CAD software for the microcomputer. The most frequently used software was AutoCAD.

Step 3. Select solution strategy(ies) from among alternatives. The Clothing and Textiles Department would use the CAD systems available for departmental use, the Lectra system (industrial CAD system) and the AutoCAD/ApparelCAD system (microcomputer system).

Step 4. Implement selected methods and means. The course, Current Topics in Clothing and Textiles - Computer Aided Design (CT 6004), would be taught fall semester 1992 using the two CAD systems to complete class assignments.

Step 5. Determine performance effectiveness. The efficiency of the two CAD systems would be compared based on the student's time to complete the final assignment and on the number of steps determined by the instructor and the researcher.

6. Revise as required. The results would then be used to make recommendations for the efficient use of CAD at Virginia Tech.

These steps guided the development of the methods and procedures used to conduct this study (Kaufman & English, 1979). Furthermore, Kaufman's model used the learners, educators, and the community as primary components of the needs assessment process and the data were collected from these primary sources for this study.

Chapter IV

METHODS AND PROCEDURES

The increased use of CAD technology by the apparel industry has prompted greater use of CAD in apparel design curricula in higher education. The CAD systems available on the market vary in terms of their efficiency and user friendliness, both of which affects the approaches used to incorporate CAD into the curricula, as well as student receptivity to CAD. Regardless, student exposure to CAD in the educational process is essential to their employability in the apparel industry.

The purposes of this study were (a) to determine how to efficiently use the CAD systems that are accessible to the Clothing and Textiles Department at Virginia Tech for the apparel design curriculum, (b) to determine students' attitudes towards using CAD, and (c) to investigate the current use of CAD at other universities with apparel design programs.

This chapter will discuss the methods and procedures used to accomplish the research objectives as follows: (a) background, (b) in-class investigation - case study, (c) student sample, (d) development of the instruments, (e) data collection (in-class investigation), (f) data analysis (in-class investigation), (g) survey of apparel design faculty, (h) development of the survey, (i) sample, and (j) data analysis. This research involved a case study investigation, and a survey administered by mail.

Background

The Clothing and Textiles Department has two CAD systems, the Lectra industrial CAD system and the AutoCAD/ApparelCAD microcomputer system. A limitation to the

CAD systems used was the Lectra software had not been upgraded since 1987 and ApparelCAD software had not been upgraded since 1990.

The Clothing and Textiles Department at Virginia Tech recognized the need to incorporate CAD into the design curriculum and purchased the Lectra system in 1987. Beginning in 1988 the Lectra system was used for a few assignments in several apparel design courses to expose students to the capabilities of CAD. This integration of CAD was limited because only one workstation was available with the Lectra; therefore, the assignments had to be extended over a longer period of time to give all students access to the system.

The need to give students more CAD experience in design courses in clothing and textiles prompted the department to investigate the use of a microcomputer CAD system. In 1989, the College of Human Resources developed an AutoCAD lab for use by the Housing, Interior Design and Resource Management Department and the Clothing and Textiles Department. The apparel design faculty investigated available CAD software with apparel applications and decided to purchase ApparelCAD, a supplemental computer program used with AutoCAD; therefore, the only expense was the purchase of the ApparelCAD software.

In-Class Investigation - Case Study

This study was based on the availability of two CAD systems at Virginia Tech and the need to determine how to efficiently use them in apparel design courses. The lack of research concerning the implementation and use of CAD in apparel design programs led to the use of qualitative research methods.

The strength of qualitative research is its flexibility that allows the research design to be refined as the developmental research questions are examined. Qualitative research is an exploratory method that helps to answer questions about the subject being researched

(Marshall & Rossman, 1989). According to Gordon and Langmaid's (1988) discussion of qualitative market research,

> qualitative research is best used for problems where the results will increase understanding, expand knowledge, clarify the real issues, generate hypotheses, identify a range of behavior, explore and explain consumer motivations, attitudes and behavior, identify distinct behavioral groups, and provide input to a future stage of research or development. (p. 3)

Gordon and Langmaid's definition of qualitative research supported the parameters of this study which involved student attitudes concerning CAD and efficient use of the two CAD systems in apparel design courses.

The case study is one method used in qualitative research and was used for this research. The purposes of case study research are to instruct and to try out, to prove or test. Marshall and Rossman (1989) stated that case study research is a strategy best used for studies that are exploratory, explanatory, or descriptive, such as this study.

This study was basically exploratory in that no research to date has documented the advantages of the available CAD systems or the efficiency of CAD systems for use in education. The lab setting for the case study was a course entitled CT 6004: Current Topics in Clothing and Textiles - Computer Aided Design. The course was taught Fall Semester 1992 and focused on CAD applications in the industry and provided students with hands on use of the Lectra system (i.e., a major supplier in the apparel industry of CAD equipment) and the AutoCAD/ApparelCAD system (i.e., CAD software for the microcomputer). This study explored the most efficient use of the two CAD systems and documented the class activities of CT 6004. It also examined student attitudes toward computers and CAD to determine whether their attitudes influenced acceptance and use of CAD in this course.

Case Study

Student Sample

The sample for the case study consisted of three female apparel design graduate students enrolled in CT 6004. Two of the students were in the master's program and the other student was in the doctoral program. These students were willing to provide details and information that would contribute to this investigation.

Development of the Instruments

Data collection for the case study approach usually involves observations and interviewing; however, other specialized techniques, such as the questionnaire, can be used to supplement these techniques. The questionnaire is used to learn the distribution of characteristics of a sample population as well as attitudes and beliefs of a sample population (Marshall & Rossman, 1989).

Student Questionnaire. The student questionnaire used in this study (Appendix A) was a modified version of the instrument used by Orzada (1990). Orzada's questionnaire was modified to make it more relevant for this study. The demographics were changed as follows: the students were asked to indicate their previous CAD experience and which apparel design courses they had taken prior to CT 6004. The course number and course title were changed to correspond with the course used in this study.

Modification to two of the original questions were as follows: Item 15 added "with a higher salary" to the end of this question, and Item 28 was clarified with the addition of "before using computer-aided design technology". Another item was added to this section, Item 34, which asked, "One of the most important skills for apparel design students to acquire is the ability to design using flat pattern techniques by computer". The last ten items were modified by changing the course number and changing the reference to the two CAD systems used in CT 6004. The student questionnaire was not pretested since it was a modification of a previously used questionnaire for which reliability had been established (Orzada, 1990).

Orzada's (1990) questionnaire borrowed items from the ACTUS attitude scale and the computer attitude scale used by Morrison (1983). The ACTUS was developed by Popovich, Hyde, Zakrajsek, and Blumer (1987). The validity of the ACTUS scale was examined by Zakrajsek, Walters, Popovich, Craft and Hampton (1990). Zakrajsek, et al. (1990) examined the convergent validity of seven computer-related attitude scales published between 1982 and 1987. The seven scales included Zolton and Chapanis' 23-item "General Statements" questionnaire, Cybernetics Attitude Scale, Attitudes toward Computer Usage Scale (ATCUS), the 20-item Computer Attitude Scale (CATT), Bannon, Marshall, and Fluegal's 14-item computer attitude scale, Nickell and Pinto's Computer Attitude Scale (NCAS), and the Computer Anxiety Rating Scale (CARS). The computer attitude scales were randomly administered to male and female students and correlations among the scales and subscales were determined. The ATCUS scale was found to have a reliability estimate of over .80. The correlations of the ATCUS scale with the other scales provided evidence of convergent validity of the ATCUS scale for measuring computer attitudes of individuals.

The student questionnaire for this study consisted of two attitude scales (a pretest and a post-test); the pretest was administered at the beginning and the post test was administered at the end of the semester. The pretest was completed by the students during the second class period of CT 6004. The first page consisted of background information: major, classification, sex, previous classroom computer activities, previous CAD experience, listing of courses where a computer had been used, and previous design courses taken prior to CT 6004. The next 34 items addressed student attitudes toward computers, toward the course, perceived importance of the subject matter, and awareness of the need for computer technology in the apparel industry. The post-test questionnaire contained 10 items related specifically to the CAD activity for each CAD system used in CT 6004. These items included the appropriateness of the CAD activity to the course, the clarity of the instructions, the CAD program and graphics, and the enhancement of design knowledge as a result of the CAD experience.

Final assignment. The instructor of CT 6004 developed the final assignment used in the course. This assignment was used as an indirect interview of the three graduate students in CT 6004 since it included questions concerning the students' attitudes and preferences for the CAD systems being used to complete each part of the final assignment. Also, since this study investigated which system was most efficient to use in the classroom, the final assignment was comprehensive and was used to determine the steps in process and the time factor.

The final assignment in CT 6004 (Appendix B) was comprehensive and required the students to use the knowledge and skills they had learned during the previous eight weeks of the course. Additionally, on the final assignment, the students were asked (a) to document the amount of time used to complete each part of the final assignment for each CAD system; (b) to list the advantages of the two CAD systems for completing each part of the final assignment; (c) to identify which CAD system they preferred to use to complete each part of the final assignment; and (d) to identify which CAD system they thought would be more time efficient if used in a class of 15 students. The students were also asked to document their time to determine if the time they used to complete the final assignment corresponded to the amount of time anticipated by the instructor based on her knowledge of the students' learning process.

The criteria used to measure the efficient use of the two CAD systems were time and steps in process. The researcher assumed that the amount of time used to complete the final assignment was positively correlated to the number of steps. A comparison of the students' time and the steps in process was used to test this assumption.

The final assignment, as developed by the instructor, consisted of three parts. Part I included dart manipulation of front and back bodice slopers as well as manipulation of the dart in the front skirt sloper. Also included in this part were pattern alterations: lengthening a front bodice, changing the waist circumference on this pattern piece, as well as the corresponding skirt pattern piece. Part II involved designing with darts, adding design lines, combining pattern pieces, and making facings. Part III focused on pattern grading. The students were required to grade the size 12 bodice front, bodice back and yoke pattern pieces used in Part II to sizes 10 and 14 using both CAD systems.

The students were given evaluation forms to complete for each of the three parts of the final assignment. The evaluation forms contained an area to log time as well as questions related to advantages of the two CAD systems, the CAD system preferred for use for the assignment, and the most efficient CAD system to use in a class with 15 students.

Data Collection - (In-Class Investigation)

The case study consisted of an in-class investigation of the CAD activities in CT 6004. The data collection involved administering a four page questionnaire to students enrolled in the course. The first three pages of the student questionnaire (Appendix A), the pretest, was administered during the second class period. The fourth page of the questionnaire, the posttest, was administered after the students completed the final assignment in CT 6004. The fourth page of the questionnaire focused on the attitudes of the students toward the Lectra and AutoCAD/ApparelCAD systems used in CT 6004 to complete the final assignment.

The format of CT 6004 was as follows: (a) the students were introduced to AutoCAD/ApparelCAD for 4 weeks and completed various small assignments to familiarize themselves with the system; (b) the students spent 4 weeks on the Lectra system receiving instructions on its use and capabilities and completed small assignments to become familiar with the system; and (c) the last 6 1/2 weeks were devoted to the final assignment (See course syllabus Appendix C). The final assignment (Appendix B) consisted of the three parts, previously discussed, each of which was to be completed using both CAD systems. The three parts involved pattern problems using the bodice and/or skirt patterns as required. Part I of the assignment involved dart manipulations and alterations. Part II involved pattern design work. Part III of the assignment involved pattern grading work.

During the eight weeks that students spent on the Lectra system and the AutoCAD/ApparelCAD system, they were introduced to all the functions and procedures they would need to complete the final assignment. The instructions for the final assignment included the order in which the students were to complete each part of the final assignment. The order was determined by the instructor. Part I and Part III of the final assignment were to be completed first on the AutoCAD/ApparelCAD system and then on the Lectra system. Part II was to be completed first on the Lectra system and then on the AutoCAD/ApparelCAD system.

The number of steps involved in completing the final assignment was determined jointly by the instructor and the researcher. The researcher logged the steps as the instructor completed the assignment on the AutoCAD/ApparelCAD system. The researcher with the aid of the instructor, completed the assignment and logged the steps involved for the Lectra system. Each part (Part I - Part III) of the final assignment was broken down into subparts or major steps by the instructor. These subparts were used to guide the students as they documented the amount of time necessary for them to complete each part of the final assignment. These subparts were used to construct the tables showing the number of steps needed to complete the final assignment.

Data Analysis - (In-Class Investigation)

Data from the student questionnaires were summarized using frequencies and content analysis. Content analysis is a technique used to convert verbal and nonverbal communications into quantitative data (Paoletti, 1982). The open ended questions from the final assignment were presented in tables, and the data were summarized in the discussion of the results. Strauss and Corbin (1990) recommend the use of open coding to analyze open ended questions. Open coding breaks down, examines, compares, conceptualizes, and categorizes data (Strauss & Corbin, 1990). The open ended questions on the final assignment related to the students' attitudes toward computers and CAD technology were analyzed using the open coding process.

Survey of Apparel Design Faculty

The survey of educators in apparel design programs was used to determine which CAD systems were being used in other programs and how they were being used. The survey was also used to determine why CAD was integrated into the design curriculum as well as what challenges had been faced by apparel design faculty using CAD in the curriculum. The results should help other clothing and textiles programs recognize what options they have available to them when considering the integration of CAD into their clothing and textiles curriculum.

Development of the Survey

The Educational CAD Use Questionnaire (Appendix D) was developed using the objectives of the study as a bases for the questions that were included. The questionnaire contained 15 items and was used to collect data concerning the following: how CAD is being taught in other apparel design programs (i.e. the course(s), the subject(s) being taught using CAD, the type of instructional materials being used to teach CAD), when CAD was first introduced into the curriculum, the type(s) of CAD system(s) being used, the number of workstations in the classroom and, if applicable, the software package being used with a microcomputer CAD system. Information was also sought on what influenced the decision to include CAD in the design curricula, why the respondents had chosen the hardware system they were using, and their future plans for CAD in the curriculum. Additional items on the questionnaire related to the respondents' interaction with the apparel industry, industry related organizations, and the CAD industry, and the challenges experienced with the integration of CAD (see Appendix F).

The format for the items on the questionnaire was forced choice except for items 14 and 15. Item 14 asked the respondent to list the date of their last hardware and/or software CAD updates, and item 15 asked the respondents to list the challenges they had met while integrating CAD in the design courses.

For the pilot test, the questionnaire was completed by three clothing and textiles professors who were teaching CAD in the design curriculum at other universities. Responses made by these professors were used to revise the questionnaire.

Sample

Individuals listed in the 1992 International Textile and Apparel Association (ITAA) Membership Directory were the population for this study. The sample was selected from those who indicated their research and teaching interest as either clothing design/fabrication/illustration and/or textile/apparel industries in the ITAA Membership Directory. A preliminary list of individuals to whom the questionnaire would be mailed was created by the researcher and was finalized with the assistance of a member of the researcher's committee who was familiar with which colleges and universities have apparel design programs.

The Educational CAD Use Questionnaire was mailed in January 1993 to 195 individuals at colleges and universities with an apparel design program. A total of 119 questionnaires were returned.

Data Analysis

The data from the questionnaire were summarized using frequencies with the exception of the last question (Number 15). This data were evaluated using the open coding method of data evaluation. Strauss and Corbin (1990) recommend the use of open coding to analyze open ended question. Open coding breaks down, examines, compares, conceptualizes, and categorizes data (Strauss & Corbin, 1990). The literature emphasized the challenges that other apparel design programs had faced in implementing CAD. These challenges were the amount of time required for instructors to learn CAD, the lack of funds available to purchase CAD hardware and software, and the decision of what to eliminate from the existing curricula so that CAD can be included in the curricula (Belleau & Bourgeois, 1991; Van De Bogart & Knoll, 1990). Other challenges found were the lack of qualified faculty to teach CAD (Koch, 1990), and the lack of instructional materials related to CAD use in apparel design (Huck & Hedrick, 1990; Koch, 1990; Steinhaus, 1988). The challenges were used as categories on which the analysis was based. These categories were presented in table format for content analysis.

Chapter V

RESULTS AND DISCUSSION

This study investigated CAD use in a Computer Aided Design course at Virginia Tech and in apparel design programs at other universities, student attitudes toward CAD, and student preferences for one CAD system over another. The results, as presented in this chapter, were based on data collected from three students enrolled in CT 6004 and from 119 faculty at other universities. The data were analyzed using frequencies and content analysis.

The results are reported by objective. The following objectives guided the study:

Objective I

To investigate the attitudes of apparel design graduate students toward using CAD technology in the classroom.

Objective II

To compare the efficiency of the AutoCAD/ApparelCAD system to the efficiency of the Lectra system as a tool to complete assignments in CT 6004.

Objective III

To compare apparel design graduate students' preference toward using the AutoCAD/ApparelCAD system versus the Lectra system for completing assignments in CT 6004.

Objective IV

To investigate the current use of CAD in the design curriculum at other colleges and universities.

Demographics and Student Backgrounds

Three female graduate students specializing in apparel product design and analysis were enrolled in CT 6004 Current Topics in Clothing and Textiles - Computer Aided Design. The students in CT 6004 were asked questions concerning prior computer usage to determine if this would influence their attitudes toward computers. The computer skills of the students varied: one student had only used the computer for class activity 1-5 times and the other two students had used the computer 11 or more times for class activity. The students were asked to list the names or course numbers of the courses in which they had used a computer. The list included: Statistics, Research Analysis, Orientation to Research, Textile Evaluation, Apparel Product Analysis, Pattern Grading, and Functional Design.

The students were asked to respond to a question concerning prior CAD experience. Two of the students had no prior experience with CAD. The third student had some exposure to the Lectra system.

The students were also asked which apparel design classes they had completed. All students had taken a flat pattern course, two had taken an advanced flat pattern course, two had taken a pattern grading course, and all of the students had taken a draping course prior to CT 6004. These were among the 20 courses Sheldon (1988) found were recommended for training apparel designers.

Results by Objectives

Objective I. To investigate the attitudes of apparel design students toward using CAD technology in the classroom.

The review of literature emphasized the importance of a person's attitude toward computers and the influence this attitude has on one's acceptance and use of computers and computer technology (Madsen & Sebastiani, 1987; Mehlhoff & Sisler, 1989). For this study, apparel design students' attitudes toward the acceptance and use of CAD in the classroom were determined by their responses to 24 items on the Student Questionnaire (Appendix A). The results were used as an indicator of the students' acceptance and use of CAD technology in CT 6004.

The students' general attitude toward computers was measured according to responses to 17 items on the Student Questionnaire. The data are summarized in Appendix E Table E.1.

In general, the students had a positive attitude toward computers. At least two of the graduate students agreed that computer technology is helpful and important for career success and for commanding a high salary, while expertise in computers is very important for getting a good job with a high salary. All of the students indicated that they liked to keep up with technological advances and either owned or would like to own a computer and preferred to use a word processor rather than a typewriter. The students also responded positively to items 21, 24, 27, and 29 regarding their ability to learn and understand how to use the computer and other high technology items; however, the students did not agree that computers reduced the importance of the individual (item 4).

The students' perceptions concerning computer technology in the apparel industry were examined with seven items on the Student Questionnaire. The importance of computer technology in the apparel industry was documented in the review of literature and influenced the examination of the students' attitudes toward the use of computer technology in the apparel industry ("Number of", 1993). A complete summary of the responses to the seven items concerning computer technology in the apparel industry is in Appendix E, Table E.2. All students agreed that computers can be used to speed up design and production. Although the students agreed that flat pattern techniques in designing apparel was possible on the computer, they did not feel manual pattern manipulation was no longer needed. They also agreed that CAD training and experience is needed by future designers prior to employment.

In regards to the U.S. apparel industry, the students agreed that the U.S. was having problems competing with imports. Two of the three students agreed that Quick Response was a strategy being used by the apparel industry to compete with apparel imports.

The investigation of attitudes of the apparel design students toward using CAD technology in CT 6004 revealed that the students had positive attitudes toward computers and the use of computer technology in the apparel industry. The students had used the computer in previous classes and this prior exposure could have influenced the students' positive attitude towards computers and computer technology.

<u>Objective II.</u> To compare the efficiency of the AutoCAD/ApparelCAD system to the efficiency of the Lectra system as a tool to complete assignments in CT 6004.

Efficiency was measured in terms of the amount of time used by the graduate students to complete the final assignment and the steps in process required to complete the final assignment. The final assignment was developed by the instructor of CT 6004 and involved flat pattern manipulation and pattern grading. The final assignment consisted of three parts: Part I was dart manipulation and alterations, Part II was pattern design, and Part III was pattern grading.

The students in CT 6004 were asked to keep a log documenting the time used to complete each part of the final assignment. Each part of the assignment was categorized by the course instructor and a log sheet was given to the students to document the amount of time used to complete each section of the final assignment.

The course instructor and the researcher standardized the assignment by logging only the steps necessary to complete each part of the final assignment on each CAD system. The standardization supplemented the students' documentation of the time used to complete the final assignment on each CAD system. Both sets of data (i.e., steps, and time used) were used to evaluate the efficiency of each CAD system.

Comparison of Student Logs

Table 1 shows the amount of time, in minutes, that each student recorded for completing Part I, Part II, and Part III using the AutoCAD/ApparelCAD system and the Lectra system. Parts II and III of the AutoCAD/ApparelCAD information are incomplete because one student failed to record the time used to complete these parts of the final assignments. The Lectra system information is also incomplete because the same student failed to record the time used to complete the final assignment. Detailed results of the students log are presented in Appendix E, Table E.3.

The amount of time recorded for each process in the assignment were similar for each student except in a few instances where one student used considerably more time than the other. The course instructor was interviewed to gain some insight into the time disparity between the two students. According to the instructor, the graduate student that used more time to complete the assignments was very ambitious in regards to learning as much as possible about the CAD systems and was not completely satisfied until she had completed the assignment to perfection. This often entailed redoing steps more than once. Therefore, the

Table 1

Total Time to Complete the Final Assignment in CT 6004

Procedures	Time in minutes for AutoCAD/ApparelCAD			Time in minutes for Lectra		
Student	1	2	3	1	2	3
Total time for Part I	207	139	181	76	65	105
Total time for Part II	240	198	-	253	85	-
Total time for Part III	545	315	-	385	195	-
Total time for Final Assignment	992	652	-	714	345	-

amount of time this particular student used was much greater than the other student who was not as intense.

The course instructor also indicated that though the two other graduate students were also interested in learning about the CAD systems, they were not as concerned with precision in line quality as the previous graduate student. Their main concern was with learning and understanding the steps in process necessary to do flat pattern work on the CAD systems, not with perfecting the steps in process and each assignment.

Comparison of CAD Systems

The steps in process that were used as the standard are presented in Appendix E Tables E.4, E.5, E.6, and E.7. The steps listed in the tables (Appendix E) are more detailed than those given to the students to document. The detailed steps were used in order to make an accurate comparison of the two CAD systems.

The data as summarized in Table 2 show that the AutoCAD/ApparelCAD system required more steps to complete the final assignment than the Lectra system. This result was

Table 2

Steps to Complete the Final Assignment Part

Procedures	Number of steps for AutoCAD	Number of steps for Lectra
Part I Dart Manipulation	87	83
Part I Alterations	101	38
Part II Designing with Darts	53	44
Part II Adding Design Lines	628	256
Part III Pattern Grading	973	196
Total Steps for the Final Assignment	1,842	617

expected since, according to Steinhaus (1988), AutoCAD software was developed for use in engineering and not for apparel design. Engineering software has to be adapted for use in other fields, since some of the program functions are not applicable to apparel design, therefore the manuals and books concerning the software are difficult to understand. This difficulty is due to the vocabulary, examples, exercises, and problems that are used that deal with machine parts, architecture, and electrical circuits (Steinhaus, 1988).

The standards (i.e., steps in process), as determined by the course instructor and researcher, provided insight regarding the differences between the two CAD systems as used for this particular class assignment. A summary of the data collected, time of the students and the standards, is presented in Table 3. In general, as the number of steps increased so did the amount of time (number of minutes) for each system. The Lectra system required fewer total steps and the overall average time for the students to complete the final assignment was also less for the Lectra system; however, the average time to complete Part II, pattern design work, was very close for both CAD systems which could indicate that either system

Table 3

Summary of Time in Minutes and Steps for the Final Assignment

Procedures	AutoCAD/ApparelCAD		Lectra	
	Avg. Time (minutes)	# of Steps	Avg. Time (minutes)	# of Steps
Part I [a]	176	188	82	121
Part II [b]	219	681	169	300
Part III [b]	430	973	290	196
Total	825	1,842	541	617

[a] Average time is based on Student 1, 2, and 3's time.
[b] Average time is based on Student 1 and 2's time.

could be efficiently used to teach this type of problem. Furthermore, the time and step disparity between AutoCAD/ApparelCAD and Lectra on Part III, pattern grading, clearly indicates that this type of assignment would be more efficiently taught on the Lectra system. Further investigation is needed to compare the AutoCAD/ApparelCAD system with the Lectra system to determine which system can be efficiently used to teach apparel design subjects in the classroom at Virginia Tech.

Objective III. **To compare graduate students' preference toward using the AutoCAD/ApparelCAD system versus the Lectra system for completing assignments in CT 6004.**

Attitude is an important part of the learning process especially when technology is involved. Therefore, for this study, student attitudes toward CT 6004, the importance of the subject matter (CAD), and the use of the computer as an instructional tool were determined by the graduate students responses to ten items on the Student Questionnaire.

Attitudes Toward the Class

Student attitudes toward CT 6004 were measured by responses to three items on the questionnaire. The statements pertained to the expected grade from the class, the amount of effort expected for the class, and whether CT 6004 was the students' favorite class. Responses of the students are presented in detail in Appendix E, Table E.8.

Although the students indicated their plans to put forth an effort to do well in the class, only one student regarded CT 6004 as one of their favorite classes. All of the students however, expected to earn at least a B in the class.

Importance of Subject Matter

Three items concerned the importance of learning flat pattern techniques by computer and manually. All of the students agreed or strongly agreed that learning flat pattern techniques on the computer would enhance their design ability. Two of the three students indicated the importance of knowing flat pattern techniques prior to using CAD technology. They also felt that acquiring the skill of flat pattern techniques on the computer was important. Student responses to these three items are presented in detail in Appendix E, Table E.9.

Computers as Instructional Tools

The review of literature denoted the importance of using computers in the educational process to prepare students for careers in the apparel industry. Four items pertaining to the use of computers as instructional tools were included on the Student Questionnaire. The students were in agreement with each of the four statements. They indicated that they liked using the computer in class, but wanted to work at their own pace. They also regarded computer activities in the classroom as exciting and wished more computer activities were included in their classes. Responses to these items are presented in Appendix E, Table E.10.

Advantages of the CAD Systems Used in the Final Assignment

After completing the final assignment the students were asked to indicate the advantages of each of the two CAD systems for the three parts of the assignment, (e.g. dart manipulation and alterations, pattern design, and pattern grading) and to indicate which system they preferred to use for the assignment, if the class contained 15 students. Details of their responses are in Appendix E, Table E.11, Table E.12, Table E.13, and Table E.14.

Final Assignment Part I.

Dart Manipulation. For the Lectra system, the advantages cited by the students included similarity to the manual method and the ability to have a full scale pattern plotted for use by the student. The advantages of the AutoCAD/ApparelCAD system were similarity to manual methods, the use of a window to work in a specific area of the pattern, and the sloper stays in one piece during the procedure.

Alterations. Rather than indicate the advantages of the AutoCAD/ApparelCAD system, one student stated a disadvantage as the stretch process and the excessive number of steps involved. Advantages indicated by the other two students included improvement over manual alterations and the ability to work in sections with the stretch process.

The advantage of the Lectra system indicated by two of the students was the quickness of the system in completing the alteration problem. Two students also indicated that the Lectra system was easier to use for the alteration problem.

Overall the students preferred to use the Lectra System to complete dart manipulation and alteration problems; however, one student thought that the AutoCAD system with five workstations would be more time efficient to complete Part I of the final assignment in a class of 15 students.

Final Assignment Part II.

Pattern Design. One student stated that there was no advantage to using the AutoCAD/ApparelCAD system for pattern design work. Advantages cited by the two other students were that it was a hardy and durable system and it was easy to apply seam allowances.

The students' responses to the advantages of using Lectra were, that although downtime was a factor, it was more efficient to use for pattern design. Another student thought facings and extensions were easy to do, while the other student stated that the work was cleaner and manipulation of the pattern was better on Lectra than with AutoCAD.

Another advantage to using AutoCAD/ApparelCAD in pattern design work mentioned by the instructor but not by the students concerned the adding of seam allowances. Patterns completed on the AutoCAD/ApparelCAD system have both the stitching and cutting lines on the completed pattern, whereas on the Lectra, only the cutting line is printed on the completed pattern.

The students all preferred to use the Lectra system for the pattern design problem that they were assigned in Part II of the Final Assignment. However, when asked which system they felt would be more time efficient to use in a class of 15 students, two responded that they felt AutoCAD/ApparelCAD with five workstations would be more efficient while the other student believed the Lectra system would be more efficient.

Final Assignment Part III.

Grading Patterns. Two students responded that there were no advantages to using AutoCAD/ApparelCAD for grading patterns. However, one student did indicate that she felt an advantage of AutoCAD/ApparelCAD was being able to use any fraction to stretch a pattern to the graded size (only 32nds of an inch is used with the Lectra system). The advantages of using the Lectra system included ability to create useable patterns, easier to see and understand the grading process, and the program was easy to use.

The students all preferred to use the Lectra system for grading patterns in Part III of their Final Assignment. Their response to the question "If you were in a class of 15 students, which system do you think would be more time efficient for the class to use for the problems in Part III?" was unanimous in favor of the Lectra system.

Attitudes Toward the CAD Systems

After completing the final assignment, the students were asked to respond to the last page of the Student Questionnaire. This page was not given to the students with the student questionnaire given during the second class period of CT 6004. This part of the questionnaire was used as a post investigation of their attitudes toward using the AutoCAD/ApparelCAD system and the Lectra system. The questionnaire contained 10 statements concerning the use of AutoCAD/ApparelCAD and Lectra for their assignments. Responses are summarized in Appendix E, Table E.15 and Table E.16.

AutoCAD/ApparelCAD. The students agreed that the CAD activities were appropriate for CT 6004 and that the graphics (drawings) were clear, but they felt too much time was involved in completing the assignments. At least two of the students felt adequately prepared to use the ApparelCAD system, but one student did not understand what she was expected to do for the CAD activity. Two students indicated they would use the skills gained from the class activities and that their awareness of the importance of accuracy in design with the CAD activities was increased. These students also agreed that they could easily visualize the pattern pieces from the pictures and information presented on the computer screen, and that they had enhanced their knowledge of flat pattern techniques by working with the CAD system. However, at least one student preferred not to use the ApparelCAD computer system to learn flat pattern techniques for apparel design.

Lectra. The students agreed that the CAD activities were appropriate for CT 6004 and that they were adequately prepared to use the Lectra system for the CAD projects. At least two of the students agreed that they understood what they were to do during the CAD activities and that the CAD projects took a reasonable amount of time to complete on the Lectra system. All of the students agreed that they had enhanced their knowledge of apparel design and flat pattern techniques using the Lectra system and that the skills gained from the CAD activity would be used in the future. One student indicated that her awareness of the importance of accuracy in design work was not enhanced through the CAD activities completed on the Lectra system. The students favored the Lectra system for learning flat pattern techniques for apparel design and agreed that they could easily visualize the pattern piece from the image presented on the computer screen. However, more students (3) felt that the graphics image on the AutoCAD/ApparelCAD system was clearer than the images on the Lectra system.

The graduate students selected Lectra as the CAD system they would prefer to use to complete the final assignment in CT 6004. The data indicated that the students could find some merit in both of the CAD systems that were used to complete the final assignment in CT 6004, but when asked to choose between the two systems they preferred to use the Lectra system.

Objective IV. To investigate the current use of CAD in the design curriculum at other colleges and universities.

The Educational CAD Use Questionnaire (Appendix D) was sent to educators at other universities to investigate how CAD was being used in their design curricula and also to get their opinions on the challenges they faced while incorporating CAD into the apparel design curriculum. One hundred and ninety five questionnaires were mailed and 119 were returned; a response rate of 61%. However of the 119 respondents, only 59 indicated that CAD was being used in the curriculum; 60 respondents indicated that CAD was not being used. Although the 60 respondents did not complete the questionnaire, they provided written comments that pertained to this study. Twelve were from colleges and universities that did not offer the apparel design option in their department, six departments responded that they were currently considering purchasing CAD equipment to be used in the classroom, and one questionnaire indicated that money problems prevented the purchase of CAD equipment for classroom use. Two of the returned questionnaires stated that the apparel design program was being terminated in the near future.

Although 59 questionnaires were useable, some table frequencies do not total 59 because several items in the survey permitted multiple responses.

CAD Use at Other Universities

Respondents were asked to identify the courses in which CAD was taught. The CAD only course was the most frequently mentioned followed by basic flat pattern, pattern grading, and advanced flat pattern (Table 4). The techniques most often taught on the CAD system were flat pattern techniques, marker making, pattern grading, and garment sketching (Table 5).

CAD was first implemented in two apparel design programs in 1982; however, in 1990 eighteen apparel design programs implemented CAD in their curriculum (Table 6). Two of the respondents were preparing to implement CAD into the design curriculum in

Table 4

Courses that Include CAD Instructions

Courses	Frequency	Percent %
Basic flat pattern	19	19
Pattern grading	13	13
CAD only	**36**	**35**
Advanced flat pattern	10	10
Other	22	21
No response	2	2
Total	100	100

Table 5

Subject(s) Taught on the CAD System

Subject(s)	Frequency	Percent %
Digitizing	34	13
Pattern grading	44	16
Marker making	42	16
Flat pattern techniques	**49**	**18**
Pattern drafting	37	14
Garment sketching	41	15
Other	23	8
Total	270	100

Table 6

The Year CAD was First Used in the Apparel Design Curriculum

Year	Frequency	Percent %
1982	2	3
1983	1	2
1984	1	2
1985	0	0
1986	2	3
1987	3	5
1988	8	14
1989	4	7
1990	**18**	**31**
1991	9	15
1992	5	8
1993	4	7
1994	2	3
Total	59	100

1994. It is interesting to note from the data in Table 6 that as many apparel design programs (18) have added CAD since 1990 as had used CAD through 1990 (18). Some of the apparel design programs had updated their CAD systems since the original purchase. The updating of CAD hardware occurred from 1986 to 1993 with the most updates being acquired in 1992, especially for IBM and MacIntosh systems (Table 7). CAD software was updated from 1987 to 1993 with the most updates also being acquired in 1992 (Table 8).

The respondents were asked to rank in importance the factor that influenced the decision to include CAD in apparel design courses (Table 9). The factor ranked number one by the most respondents was apparel industry needs. The factor ranked second by more

Table 7

Acquisition of Last Update of Hardware

Hardware system	1986	1987	1988	1989	1990	1991	1992	1993	Total
Assyst	0	0	0	0	0	0	1	0	1
MicroDesign	0	0	1	0	2	0	2	0	5
Lectra	1	0	1	0	1	0	0	0	3
IBM	0	1	1	3	1	1	8	3	**18**
MacIntosh	0	0	0	0	1	1	4	1	7
Gerber/Camsco	0	0	0	0	0	0	0	1	1
Amiga	0	1	0	0	0	0	0	0	1
CDI	0	0	0	0	1	0	1	0	1
System 6 MKS	0	0	0	0	0	0	1	0	1
Next	0	0	0	0	0	0	1	0	1
Total	1	2	3	3	6	2	**18**	5	40

Table 8

Acquisition of Last Update of Software

Software	1987	1988	1989	1990	1991	1992	1993	Unknown	Total
Assyst	0	0	0	0	0	1	0	1	2
MicroDesign	0	0	0	1	0	3	1	0	5
Lectra	0	1	0	1	1	1	0	0	4
PAD	0	0	0	0	1	0	1	0	2
AutoCAD	0	0	1	4	3	7	4	0	**19**
PDS/GMS	0	0	0	0	0	2	1	0	3
MicroDesign II	0	0	0	0	0	1	0	0	1
ApparelCAD	0	0	0	0	0	2	2	1	5
PC Pattern	0	0	0	0	0	1	0	0	1
Gerber	0	0	0	0	0	1	1	0	2
Amiga	0	1	0	0	0	0	0	0	1
Designer	0	0	0	0	0	1	0	0	1
Studio 8	0	0	0	0	1	0	0	0	1
ModaCAD	0	0	0	0	0	1	1	0	2
Investronica	0	0	0	0	1	0	0	0	1
VersaCad	0	0	0	0	0	1	0	0	1
AuraCAD	0	0	0	0	1	0	0	0	1
MKS	0	0	0	0	0	1	0	0	1
MacDraw Pro	0	0	0	0	0	1	0	0	1
CDI 2D	0	0	0	1	0	0	0	0	1
Total	0	2	1	7	8	**24**	11	2	55

Table 9

Factors that Influenced the Decision to Include CAD in Apparel Design Courses

Factors	Rank order 1	2	3	4	5	6	Checked but not ranked	Total
Industry Needs	31	3	2	0	0	0	12	48
Faculty/Programs at other universities	6	12	6	3	0	0	4	31
Existing Equipment	2	1	4	4	1	2	3	17
Advice of apparel manufacturer	0	8	3	0	4	0	8	23
Specific funding	4	5	4	2	3	0	1	19
Others	1	5	0	0	0	0	3	9

respondents was faculty/programs at other universities. Besides the factors listed on the questionnaire, the respondents indicated other factors that influenced their decision. These included working with CAD vendors, advice of the department's advisory board members, and student needs, to name a few (Appendix E, Table E.17).

The respondents were asked what type(s) of CAD system(s) they were using and how many workstation(s) they had for each system (Table 10). Fifteen apparel design programs reported using more than one CAD system for instruction in the classroom. The IBM microcomputer based CAD system was used in the classroom more than any of the CAD systems listed by the respondents. The number of workstations available for use with the microcomputer based CAD systems ranged from one to two to over 50 workstations with more apparel design programs listing the use of 15-24 workstations. Microdynamics was the next most extensively used CAD system in the apparel design classroom. The number of workstations that were being used in the classroom for the Microdynamics industrial CAD

Table 10

CAD Systems Being Used and the Number of Workstations

# of Work stations	IBM	Micro-dynamics	Mac Intosh	ModaCA D	Lectra	Other	Total
1 - 2	5	8	4	3	4	5	**29**
3 - 4	1	3	0	1	0	3	8
5 - 6	5	3	1	0	0	1	10
7 - 8	0	0	0	0	0	0	0
9 - 10	3	0	0	0	0	0	3
11 - 14	5	0	1	0	0	0	6
15 - 24	6	0	4	1	0	1	12
25 - 34	2	0	1	0	0	0	3
35 - 49	0	0	0	0	0	0	0
over 50	1	0	1	0	0	0	2
Unknown	5	0	1	1	0	2	9
Total response	**33**	14	13	6	4	12	82

system was one to six workstations with the most programs using one to two workstations; however, some of the questionnaires returned did not list the number of workstations available but did indicate the type of CAD systems being used by the apparel design department. In general one to two workstations regardless of the system type was indicated by more respondents.

The respondents were asked what type of CAD software(s) they were using if they were using IBM (or compatible) or MacIntosh computer (Table 11). The review of literature indicated that AutoCAD was currently being used by many apparel design programs (Dockery, 1989; Huck & Hedrick, 1990; Miller, 1990a; Steinhaus, 1988). The results of this

Table 11

CAD Software Being Used

Software	Frequency	Percent %
AutoCAD	**36**	**39**
PC Pattern	8	9
ApparelCAD	16	17
VersaCAD	1	1
BetaCAD	2	2
Other	14	15
No response	15	16
Total	92	100

study confirmed that the most popular CAD software being used on the microcomputer was AutoCAD; however, 15 respondents did not answer the question concerning which CAD software was being used in the classroom. The supplemental CAD programs (i.e., ApparelCAD, PC Pattern, and BetaCAD) were also being used by 26 apparel design programs in conjunction with AutoCAD; of those, ApparelCAD was used more frequently.

The respondents were asked why they had chosen the hardware system they were now using. The number one reason for choosing the hardware system that was being used to teach CAD to the apparel design students was that the equipment was already available (Table 12). This practice of sharing or using available CAD equipment was also mentioned in the review of literature (Koch, 1990: Racine, 1993). The next reason for choosing the hardware system that they were using was the cost of the system.

The review of literature indicated the difficulty of teaching CAD in the classroom was due to the lack of instructional material (Steinhaus 1988). The majority of the materials that were being used by the respondents in this study to teach CAD was developed by the

Table 12

Reason(s) for Choosing the Hardware System Now Being Used

Reason(s)	Frequency	Percent %
Cost	18	21
Industry incentive	8	9
Advice of others	11	13
Donated equipment	7	8
Equipment available	**27**	**31**
Other	16	18
Total	87	100

instructor (Table 13). The most popular tutorial/textbook being used in the classroom was the book I CAD...Can You?. Some programs were using AutoCAD books and manuals that can be purchased in bookstores while others were using the manuals that accompanied the software to develop handouts and assignments for the class.

Table 13

Instructional Aide(s) that are Being Used to Teach CAD

Instructional aide(s)	Frequency	Percent %
Software vendor	21	26
Department developed	**28**	**34**
Tutorial/textbook	16	20
Other	13	16
No response	3	4
Total	81	100

When asked to specify plans for the next 5 years, the apparel design departments now using CAD indicated more than one activity was planned (Table 14). The activities indicated by most of the respondents were to increase CAD time in courses, to upgrade software, to increase CAD stations, and to upgrade hardware. Additional plans indicated by fewer respondents were adding textile design, adding a CAD station, and cancelling the program.

Table 14

Plans for the Next 5 Years

Plans	Frequency	Percent %
Increase CAD stations	34	22
Increase CAD time in courses	**41**	**27**
Upgrade hardware	24	16
Upgrade software	37	24
Purchase different hardware	5	3
Purchase different software	8	5
Other	5	3
Total	154	100

Respondents were asked to write in the challenges they had met when integrating CAD into the design courses. The actual responses are listed in Appendix F. These responses were quantified by the open coding process using the difficulties mentioned by Belleau and Bourgeois, (1991); Huck and Hedrick, (1990); Koch, (1990); Steinhaus, (1988); and Van De Bogart and Knoll, (1990). The lack of available funds to purchase equipment and the lack of knowledgeable instructors were the more frequent responses (Table 15).

Table 15

Challenges of Integrating CAD in Design Courses

Challenge	Frequency
Funding	**12**
Time consuming to learn	4
Training and/or knowledgeable instructors	**11**
Lack of instructional material	7
Integrating into the design courses	7
Other	44
Total	85

Apparel design programs at other colleges and universities are teaching CAD in the classroom using industrial CAD systems and/or microcomputer CAD systems. This implementation of CAD into the design curriculum was influenced by the apparel industry's need to employ apparel designers with knowledge of and experience with CAD. Although apparel design programs reported numerous challenges of CAD integration, many programs still continue to make plans for upgrading and purchasing CAD equipment, as well as increasing CAD usage in the classroom.

In summary, the results of this study support research by Popovich, Hyde, Zakrajsek, and Blumer (1987); Mehlhoff and Sisler (1989); and Bushell and Rabolt (1992) which contended that prior use of computers effect positive attitudes toward computers and CAD technology. The students in CT 6004 expressed preference for using the Lectra system because less time was needed to complete the three parts of the final assignment. This suggests the Lectra system was more efficient to use for this assignment because it required fewer steps and less time than AutoCAD/ApparelCAD. The results of this research also illustrates the growing use of CAD technology in clothing and textile programs in higher education. The most popular CAD system being used in the classroom was the IBM (or compatible) microcomputer system with AutoCAD software.

Chapter VI

SUMMARY, CONCLUSIONS, IMPLICATIONS, and RECOMMENDATIONS

The influx of imported goods into the U.S. has forced the apparel industry to investigate ways to compete in the world market. Many strategies were tested in the 1980's but the concept of Quick Response (QR) evolved as the most advantageous strategy to use as viewed by the textile industry, the apparel industry, and the retail industry (Kincade, Cassill, & Williamson, 1993; Sheldon, 1988). The apparel industry began to automate design and production processes to facilitate the QR strategy of flexibility and speed in providing products as the customer needed them. Automation of the design process was achieved with the development of CAD for the textile and apparel industries.

Although utilization of this new technology increased in use, the industry lacked qualified personnel to operate the sophisticated systems. This presented a challenge at institutions of higher education as clothing and textiles programs began to integrate CAD into the curriculum in order to prepare students for these positions in the industry.

Kallal and Fraser (1984) reported that larger apparel manufacturers were hiring designers with college degrees and concluded that four year programs with CAD in the curriculum better prepared students for employment in the apparel industry. They also implied that incorporating CAD in the curriculum would improve designers' attitudes toward CAD as a design tool and also their acceptance of CAD in the workroom.

A positive attitude toward computers and CAD technology enhances a student's ability to be hired by the apparel industry. The student's attitude toward using CAD as a design tool in the industry is also enhanced by exposure to CAD in their design courses (Orzada, 1990; Belleau & Bourgeois, 1991; Belleau, Orzada, & Wozniak, 1992).

This research was conducted (a) to determine how to efficiently use the CAD systems that are accessible to the Clothing and Textiles Department at Virginia Tech for the apparel design curriculum, (b) to determine students' attitudes towards using CAD, and (c) to investigate the current use of CAD at other universities with apparel design programs. This chapter presents the summary, conclusions, implications, and recommendations for future research.

Summary

This study was exploratory, and the data gathered were both qualitative and quantitative. A case study approach using a CAD course (CT 6004) as the lab setting was used to explore CAD use on two systems available to the Clothing and Textiles Department at Virginia Tech. A mail questionnaire was developed to investigate CAD use in apparel design programs at other colleges and universities.

The objectives of the study were as follows:

Objective I

To investigate the attitudes of apparel design graduate students toward using CAD technology in the classroom.

Objective II

To compare the efficiency of the AutoCAD/ApparelCAD system to the efficiency of the Lectra system as a tool to complete assignments in CT 6004.

Objective III

To compare apparel design graduate students' preferences toward using the AutoCAD/ApparelCAD system versus the Lectra system.

Objective IV

To investigate the current use of CAD in the design curriculum at other colleges and universities.

Objective I and findings. CT 6004 Current Topics in Clothing and Textiles - Computer Aided Design was an elective course that focused on CAD applications in product development, pattern design, and pre-assembly functions in the apparel industry. The course also provided students with hands on use of two CAD systems, a Lectra system with one workstation and five microcomputer systems with AutoCAD/ApparelCAD software.

For the case study, a questionnaire was developed to assess student attitudes toward computers and toward CAD. The first three pages of the four page Student Questionnaire were administered during the second class period of CT 6004; and the last page was administered after the students had completed the final assignment. The last page of the questionnaire focused on the students' attitudes toward the two CAD systems used to complete the final assignment.

Results showed that the three graduate students enrolled in CT 6004 had positive attitudes toward computers and the use of CAD in the classroom. The students agreed that computers can be used to speed up design and production in the apparel industry. They also agreed that CAD training and experience is needed by future designers prior to employment.

Objective II and III and findings. The criteria for measuring the efficient use of the two CAD systems in CT 6004 were the amount of time each student used to complete each part of the final assignment and the number of steps that were needed to complete each part of the final assignment as determined by the instructor and researcher. The final assignment in CT 6004 (Appendix B) was a comprehensive exercise developed by the instructor. The students were given evaluation sheets to log the time spent doing their assignments and to obtain their opinions toward using the two CAD systems for the final assignment. The final assignment involved using bodice and skirt slopers for dart manipulation and alterations, pattern design work, and pattern grading.

The results indicated that the Lectra system required the fewest number of steps to complete the final assignment. The Lectra system also required the least amount of time for each part of the final assignment.

The students indicated their preference for using the Lectra system as opposed to the AutoCAD/ApparelCAD system to complete the final assignment in CT 6004. The specific reason for this preference was not given, but based on the amount of time used by each student to complete the final assignment, the Lectra system was probably selected because it took the least amount of time. Therefore, the student's attitudes were more positive toward the Lectra system than the AutoCAD/ApparelCAD system for completing the final assignment in CT 6004.

Objective IV and findings. The Educational CAD Use Questionnaire (Appendix D) was developed to investigate how other clothing and textiles programs use CAD in their apparel design curriculum, the type(s) of CAD system(s) used by these programs, and the future plans for CAD in the apparel design curriculum.

Based on the survey results, CAD was first used in the apparel design curriculum in 1982 with the largest increase in the implementation of CAD occurring in 1990. The influential factors in the decision to include CAD in the apparel design curriculum were the needs of the apparel industry, the implementation of CAD into the curriculum at other colleges and universities, and the advice of apparel manufacturers. The respondents indicated that CAD was taught in CAD only courses, flat pattern courses, and pattern grading courses for flat pattern techniques (18%), pattern grading (16%), and marker making (16%). In addition, the course materials that were being used for CAD instruction were developed within the department or provided by the software vendor.

CAD systems used in the classroom in these apparel design programs were industrial CAD systems and/or microcomputer CAD systems. The microcomputer systems were frequently chosen because they were already available for use in the apparel design program. The most popular CAD hardware was the IBM (or compatible) microcomputer system and the most frequently used software on these systems was AutoCAD.

Results indicated that the most frequent challenge met by the apparel design programs was finding the funds to purchase a CAD system. Several apparel design respondents indicated plans to upgrade the CAD hardware and software currently used, as well as increasing the number of CAD stations in the classroom. Several apparel design programs also wanted to increase the use of CAD in apparel design courses.

Conclusions and Implications

As the apparel industry continues to increase their investment in CAD technology, a need is created for pre-production department employees (i.e. designers, patternmakers, etc.) who are knowledgeable about computers and their use in the apparel industry (DeWitt, 1991). Individuals seeking employment in any of the pre-production departments would be more employable if they have experience using CAD. Madsen and Sebastiani (1987) found that attitudes were important determinants of how well an individual adapts to new technology such as CAD. Orzada (1990) found that the students in her study had positive attitudes towards computers, which influenced their positive acceptance of the CAD system that was used for her study. Although the sample for this study was small, the results indicated that the students' attitudes were positive given their past experiences with computers and their realization that computer skills, CAD specifically, are important criteria for employability in the textile and apparel industries. Apparel design programs will need to provide exposure to computers and CAD to encourage a positive attitude by students toward this technology. This positive attitude is of prime importance in the adoption of computer technology in the textile and apparel industry by future employees.

The apparel design graduate students in this study agreed that computers can be used to speed up design and production and to execute flat pattern techniques. These students, however, did not feel that the computer would make manual pattern manipulation obsolete. They also agreed that CAD training and experience would be needed by future designers prior to employment. Although CAD is becoming more prevalent in the industry, designers still need training in basic flat pattern techniques in order to understand the concepts before applying them on the computer.

According to Sheldon and Regan (1990) the lack of funds and the prohibitive cost of industrial CAD equipment has prompted the use of the microcomputer and CAD software in many clothing and textile departments. This use was supported by the results of this study which indicated that the most popular CAD system being used at other colleges and universities with apparel design programs was the microcomputer. Microcomputers are more affordable than industrial CAD systems because the equipment and CAD software can be shared by other departments on campus, which is exemplified at Virginia Tech. The size and cost of microcomputers enable the lab to be equipped with more workstations for student use, whereas the size and cost of industrial CAD equipment limit the number of workstations that can be purchased and made available for students.

CAD software for design is evolving, however, the results of this study indicate the need for software that is specific to apparel design, is user friendly, and is accompanied by instructional materials. Most of the apparel design faculty surveyed indicated that they had to develop instructional materials to assist students with using the CAD systems. Thus, publishers should become more aware of the need to develop more literature related to CAD use in apparel design.

For those departments considering adding CAD to their curriculum, the major considerations are cost, space, and accessibility for students. The results of this study indicate that microcomputers are more cost efficient, take up less space, and are more accessible to students with the availability of more workstations; however, they require more time and steps to complete a given assignment. The students in CT 6004, felt the industrial CAD system was more efficient because it required the least amount of time to complete the final assignment. If a program can afford both, this would allow students to gain experience on a system used in industry as well as have the convenience of the microcomputer to enhance their skills with flat pattern techniques. In ideal situations, it would be advantageous to combine both systems via an interface. By interfacing the two systems, the industrial software program could be imported to the microcomputer and full scale plots of the pattern could be prepared. CAD vendors should take advantage of this need to produce systems where microcomputers can be interfaced with the industrial system, since the cost of microcomputers and accompanying software is more affordable for apparel design programs.

The literature (Machin, 1991; Madsen & Sebastiani, 1987) alludes to the importance of attitudes in the acceptance and use of computer technology. The students in this study had positive attitudes towards computers on the pretest, which suggests they would maintain this attitude after using CAD in the classroom. The students after using CAD in the classroom were given a posttest and their attitudes towards computers remained positive. The more exposure that an individual has to computers the more positive the attitude will be and the individual will be more willing to use computers. This exposure is also important for the apparel designer who needs to have a positive attitude toward CAD technology which is increasingly being used in the apparel industry to automate the design process.

Recommendations for Use of the Study

The findings from this study could be used to assist other apparel design programs that are considering purchasing CAD. The information related to cost efficiency and task efficiency will assist other programs in reaching a decision regarding what CAD system to purchase. The instructional materials developed for the CAD course, CT 6004, can serve as a guide for the development of other CAD related materials.

Recommendations for Further Study

- Repeat in a secondary school with a larger sample size that can be divided into two groups. One group would complete all the assignments on the Lectra system first before receiving any instructions on the AutoCAD/ApparelCAD system. The other group would receive instructions on the AutoCAD/ApparelCAD system first, completing all the assignments on that system before receiving instructions on the Lectra system. This method would indicate whether CAD skills were transferable from system to system.
- Investigate whether apparel designers that were trained using AutoCAD, transferred that knowledge to the CAD system being used in the work place.
- Repeat the methods used in this study in other disciplines (i.e., engineering, architecture, and interior design) to measure efficiency of CAD systems.

- Conduct a study that compares the supplemental apparel design software programs that can be used with AutoCAD.
- Conduct a study that compares the industrial CAD systems available for apparel manufacturers.

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Appendices

Appendix A

STUDENT QUESTIONNAIRE

Please circle the number of your answer.

Your major

1. Apparel Design
2. Merchandising
3. Textile Science
4. Economics/Business in Clothing & Textiles
5. Other______________________________

Your Classification

1. Junior
2. Senior
3. Graduate Student
4. Other _______

Your Sex

1. Male
2. Female

How many times have you worked on a computer as a part of a class activity with in the last 10 years?

1. Never
2. 1-5
3. 6-10
4. 11 or more

Have you had previous CAD experience before taking this course?

___ no prior experience
___ course in college
___ prior work experience
___ course in trade school
___ seminars
___ worked for a CAD vendor
___ other, please specify______________________________________

If you have had prior CAD experience on what system have you had this experience?

<u>Type of system</u>

___ CDI
___ Gerber
___ Lectra
___ Mechanix
___ ModaCad
___ Microdynamics
___other (please specify)__________________________________

Please list the names or course numbers of all the courses you have taken in which you have used a computer.

____

____

____

Please check which of the following courses you have had prior to this class:

___ Flat Pattern
___ Draping
___ Advanced Flat Pattern
___ Pattern Grading
___ Workshops that dealt with any of the above subject(s). If so what subject(s)_______________________________________.

Computer technology has become an important part of the apparel industry. As apparel design students, your attitudes toward computers and usage of the computer-aided design system are important to us. Please indicate your agreement or disagreement with the following statements by circling the number of the response that describes your feelings.

STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
5	4	3	2	1

1. The U.S. apparel industry is having problems competing with imported apparel products. 5 4 3 2 1
2. I think that computers and other technological advances have helped to improve our lives. 5 4 3 2 1
3. Computer technology can speed up apparel design and production processes. 5 4 3 2 1
4. With computers, the individual will not count for very much anymore. 5 4 3 2 1
5. Manual pattern manipulation is not necessary when computer-aided design systems are available. 5 4 3 2 1
6. Quick Response is a strategy used by the apparel industry to compete with imported apparel products. 5 4 3 2 1
7. If I don't learn how to use computers, it will be difficult to be successful in any professional career. 5 4 3 2 1
8. I like it when we use computers in my classes. 5 4 3 2 1
9. I like being able to work at my own pace on the computer. 5 4 3 2 1
10. I put forth a great deal of effort to do well in CT 6004. 5 4 3 2 1
11. I would like to own, or do own, a computer. 5 4 3 2 1
12. It is possible to use the computer to design apparel using flat pattern techniques. 5 4 3 2 1
13. I will not get as high a salary if I don't know how to use a computer. 5 4 3 2 1
14. Learning flat pattern design techniques by computer will enhance my design ability. 5 4 3 2 1
15. If I know about computers I can get a higher status job with a higher salary. 5 4 3 2 1
16. I expect to earn at least a B in CT 6004. 5 4 3 2 1
17. Expertise in computers is of utmost importance if I want to get a good job. 5 4 3 2 1

18. Only a few experts really understand how computers work. 5 4 3 2 1

19. Computers can make serious mistakes because they fail to take the human factor into account. 5 4 3 2 1

20. I like to keep up with technological advances. 5 4 3 2 1

21. It is extremely difficult to learn a computer language. 5 4 3 2 1

22. I need to have experience using computer-aided design equipment. 5 4 3 2 1

23. Computer activities in the classroom are exciting. 5 4 3 2 1

24. I prefer not to learn how to use a computer. 5 4 3 2 1

25. I would prefer to type a paper on a word processor than on a typewriter. 5 4 3 2 1

26. I wish there were more computer activities in my classes. 5 4 3 2 1

27. I will never understand how to use a computer. 5 4 3 2 1

28. One of the most important skills for apparel design students to acquire is the ability to design using flat pattern techniques. 5 4 3 2 1

29. I do not like to program electronic items such as VCR's and microwave ovens. 5 4 3 2 1

30. CT 6004 Current Topics in Clothing and Textiles (Computer-aided Design) is one of my favorite classes. 5 4 3 2 1

31. Computers help to create unemployment. 5 4 3 2 1

32. Future designers will need experience with computerized apparel design and production equipment before they enter the industry. 5 4 3 2 1

33. Using a computer is too time consuming. 5 4 3 2 1

34. One of the most important skills for apparel design students to acquire is the ability to design using flat pattern techniques by computer 5 4 3 2 1

This section of the questionnaire is designed to investigate your attitudes towards the computer-aided design activity you have just completed. Please indicate you agreement or disagreement with the following statements by circling the number of the response that describes your feelings.

STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
5	4	3	2	1

		ApparelCAD	Lectra
35.	I had no problem understanding what I was to do during the computer-aided design activity.	5 4 3 2 1	5 4 3 2 1
36.	The computer-aided design activity was appropriate to CT 6004.	5 4 3 2 1	5 4 3 2 1
37.	It was easy for me to visualize the pattern piece from the pictures and information presented on the computer screen.	5 4 3 2 1	5 4 3 2 1
38.	The computer project took a reasonable amount of time to complete.	5 4 3 2 1	5 4 3 2 1
39.	I felt adequately prepared to use the computer to complete the computer-aided design project.	5 4 3 2 1	5 4 3 2 1
40.	The graphics (drawings) in the computer program were clear.	5 4 3 2 1	5 4 3 2 1
41.	I like the idea of using the computer to learn apparel design using flat pattern techniques.	5 4 3 2 1	5 4 3 2 1
42.	I will use the skills I gained from the computer-aided design activity in the future.	5 4 3 2 1	5 4 3 2 1
43.	The computer-aided design activity made me more aware of the importance of accuracy in my designs.	5 4 3 2 1	5 4 3 2 1
44.	I enhanced my knowledge of apparel design using flat pattern techniques by working with the computer aided design system.	5 4 3 2 1	5 4 3 2 1

Appendix B

CT 6004 Computer Aided Design
Final Assignment

The following problems should be completed on the Lectra and the AutoCAD CAD systems in the order specified in each of Parts I, II, and III of the assignment. Read through the evaluation for each assignment before starting the assignment.

Due dates:

Part I - Due November 10, 1992, 8:00 a.m.
Part II - Due December 1, 1992, 8:00 a.m.
Part III - Due December 15, 1992, 8:00 a.m.

When doing the pattern work on the Lectra, begin with the size 12 basic bodice front and back and the basic skirt front and back that were placed in your file at the beginning of the semester. When doing pattern work on AutoCAD, retrieve the basic sloper pieces in size 12 from the sloper menu in ApparelCAd.

Since the laser printer may not be available or the C drive may be full on it, print out your work on the dot matrix printer on the table with the computers that have ApparelCad on them. In case they are not all hooked up to the printer, you may have to use a specific computer near the dot matrix printer.

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

CT 6004 Computer Aided Design

Final Problem Set

Part I: Complete all problems in Part I first on the AutoCAD system; then complete the same problems on the Lectra system. Due November 10, 8:00 a.m.

Dart Manipulations

- Move shoulder dart in back bodice to the neck.
- Move the bust fitting dart in the bodice front from the side seam to the shoulder.
- Combine the side seam bust fitting dart in the bodice front with dart in the waistline.
- Move waistline dart (two if pattern has two) to the tail of the basic skirt front to make flared skirt.

Print each problem. You may print two at a time by putting the two in one window.

Alterations

Copy the pattern piece before beginning the alteration on AutoCAD and make alteration on the copied piece. Dimension and print out both pattern pieces to hand in. On Lectra, print out original BI sloper and the modified BI.

- Lengthen front bodice at the waist by 1/2".
- Decrease waist circumference on same bodice front by 1/4" (1" is needed in total circumference).
- Alter basic skirt front to correspond with the above alteration made in the bodice front. Be sure the waist line darts on skirt and bodice still match when alterations are completed.

Print out each problem (original and altered pattern) with AutoCAD to fit page.

Complete the above problems a second time on the Lectra system. Plot altered pattern in 1/2 scale. They can be checked against the originals plotted in dart manipulation problems.

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

Part I

Please keep a log on the amount of time you spend on each problem. Begin counting time at program menu following naming or editing a drawing file on AutoCAD. Include steps to save. Begin counting time on Lectra at MIB screen (one with pattern pieces visible at top of screen). Include to save.

	Computer System			
	AutoCAD		Lectra	
Time	Time start	Time fin.	Time start	Time fin.
Dart Manipulation Problems				
.shoulder dart to neck				
.bust dart to shoulder				
.combined dart				
.darts to flare				
Alterations				
.lengthen				
.decrease bodice waist circum.				
.decrease skirt waist circum.				

Advantage(s) of doing dart manipulation problems on AutoCAD

____

____

Advantage(s) of doing dart manipulation problems on Lectra

____

____

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

Advantage(s) of doing alteration problems on AutoCAD ______________________________

____

____

Advantage(s) of doing alteration problems on Lectra ______________________________

____

____

Which system would you prefer to use for dart manipulation?
Lectra _______
AutoCAD___________

Which system would you prefer to use for alteration problems?
Lectra________
AutoCAD__________

If you were in a class of 15 students, which system do you think would be more efficient for the class to use for problems in Part I?

The Lectra system with one work station_____

The AutoCAD with five work stations_

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

Part II - Complete problems first on the Lectra System; then do the problems on AutoCAD - Due December 1, 8 a.m.

Be sure that all seams created through design lines contain notches.

Designing with Darts

. Convert darts in back bodice to a princess line.

. Convert darts in front bodice to a princess line.

(Not part of the following design problems.) Print to fit page on AutoCAD; plot in 1/2 scale on Lectra.

Adding Design Lines/Combining Pattern Pieces/Facing

(Begin the following problems on original basic slopers. Modify the slopers and make pattern pieces for the sketched design)

. Add button extension on center front of front bodice
. Make cut-on facing for neck and button closure for bodice front
. Make front armscye facing
. Make yoke design line in bodice front; separate pieces

. Make back armscye facing
. Make back neck facing
. Move shoulder dart in back bodice to armscye at an appropriate yoke line
. Make back yoke line; separate pieces

. Butt front and back yokes at shoulder
. Convert waist line darts in back and front bodices to gathers
. Add seam allowances where needed
. Add hems where needed.

Label all pattern pieces. (Basic Image file name will be recorded on Lectra plotted pieces; use text command to label pieces done on AutoCAD that are not already labeled.)

Plot in 1/2 scale on Lectra; print to fit page on AutoCAD. Hand in.

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

Part II

Please keep a log of the time spent on each CAD system to complete your pattern work. Begin and end counting time at same screens as for Part I.

	Computer System			
	AutoCAD		Lectra	
<u>Time</u>	Time start	Time fin.	Time start	Time fin.
.add button extension				
.make facings				
.creating design lines/ separating pieces				
.add seam allowances				

Advantages of doing pattern work on Lectra______________________________

____

____

Advantages of doing pattern work on AutoCAD___________________________

____

____

Which system would you prefer to use for the pattern work?
Lectra _______
AutoCAD _________

If you were in a class of 15 students, which system do you think would be more efficient for the class to use for problems in Part II?

The Lectra system with one work station___________

The AutoCAD with five work stations_______

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

Part III - Due December 15, 8:00 a.m.

Grade Rules - Complete problems first on the AutoCAD system; then complete them on Lectra system

Determine grade rules needed to grade the bodice front, bodice back, and yoke pattern pieces to sizes 10 and 14. Use your existing grade rules where possible. Write additional rules needed to grade the modified pattern pieces.
Use the grade rules to determine how much to move a point on the pattern and use the information from the pattern grading book that shows how the body grows between sizes to determine where and how much to stretch the pattern on AutoCAD.

Grade bodice front, back, and yoke.

On AutoCAD, copy each pattern piece twice for the sketched design pattern and grade one copied piece to a size 14 and the second copied piece to a size 10. Dimension all three pieces and print in one window or to fit one page. Repeat the process for each of the three pattern pieces.

On Lectra, apply grade rules to the three pattern pieces. Plot nested pieces in 1/2 scale.

CT 6004 Computer Aided Design
Final Problem Set - Evaluation

Part III

Please keep a log on the time it takes to complete the grading on each system. Begin and end counting time at the same points in the procedures as for Parts I and II.

	Computer Systems			
	AutoCAD		Lectra	
Time	Time start	Time fin.	Time start	Time fin.
.establish grade rules				
.input into computer				
.apply grade to pattern				
.check pattern to be sure grade has been applied correctly				

Advantages to grading pattern on AutoCAD____________________________________

____

____

Advantages to grading pattern on Lectra______________________________________

____

____

Which system would you prefer to use for grading the pattern?
Lectra ____
AutoCAD____

If you were in a class of 15 students, which system do you think would be more efficient for the class to use for the problems in Part III?

The Lectra system with one work station _____
The AutoCAD with five work stations ______

Appendix C

CT 6004 CAD - Class Schedule

AutoCAD/ApparelCAD introduction and problems

August 25	Computer aided design applications in the industry Introduction to course

August 27	Introduction to AutoCAD
	Menus, command line
	Draw commands
	    lines, circles, arcs
	Modify commands
	    erase, move, extend, trim
	Save
	Print

Sept. 1	More basic AutoCAD commands
	Construct commands
	    copy, mirror, array, offset
	Modify commands
	    rotate, break
	Display commands
	    zoom, previous, etc.
	F keys
	    ortho, grid
	Osnap commands

Sept 3	ApparelCAD Croquis Sketch assignment - Use croquis to sketch and original design. Due Sept. 10.
Sept. 8	Work on sketch assignment.

Sept. 10	ApparelCAD
	Sloper problems. Due Sept. 17.
	    dart rotation
	    design lines
	    button extension
	    facings

Sept. 15	Work on sloper problems

Sept. 17	Pattern grading and alterations
	    Stretch command
	    Dimensioning commands
	Grading and alteration problems due Sept. 24

Sept. 22	Grading and alteration problems
Sept. 24	Complete grading and alteration problems

Sept. 29	Introduction to Lectra Computer System Digitizing MIB
October 1	MIB menu Manipulating grade points Transferring darts Facings (seam allowances) Saving
October 6	Digitize back and front bodices into Lectra computer; Pattern design - modify garment pieces by putting in whatever design features that includes transferring darts. Plot pattern pieces in 1/4 scale. Due Oct. 9
October 8	Add seam allowances on pieces; Mirror pieces that would be cut on the fold in a home sewing layout. Input grade rules into computer file.
October 13	Make a marker for a plaid fabric in sizes 10, 12, and 14 (specify plaid size, i.e. 2" repeat). Due October 16.
October 15	Use sketch pad on Lectra
October 20	Use sketch command on AutoCAD. Use text commands.
October 22	Grade bodice on Lectra Write grade rules for bodice Apply grade rules in computer Plot graded pattern in sizes 10, 12, and 14 Due October 27.
October 27	Complete grading problem
October 29	Assign Final problem (See Final Problem Assignment)
October 29 - November 10	Part I of final problem
November 10 - December 1	Part II of final problem
December 1 - December 15	Part III of final problem

Appendix D

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Department of Clothing and Textiles
College of Human Resources
Blacksburg, Virginia 24061-0410

January 18, 1993

Dear Educator:

The apparel industry uses advanced technologies to help speed the manufacturing processes and achieve the goal of Quick Response. One of the technologies that is being used in the pre-production phase is computer-aided design (CAD). The challenge to all colleges and universities with apparel design programs is how do we go about introducing CAD to the students so that they are more employable in the apparel industry. As a graduate student in the masters program at Virginia Tech, I have chosen to study the issue of implementing CAD in the design curriculum. I am asking for your input on how you have introduced or plan to introduce CAD into the design curriculum.

Please take a few minutes to answer the enclosed questionnaire and return it to me in the self addressed stamped envelope by February 8, 1993. I also ask that if you are not the educator in your department who works with CAD in the curriculum that you please give the questionnaire to that individual who does. Your participation in filling out and returning the questionnaire is very much appreciated.

Your response to the questionnaire will be confidential. If you wish to receive a copy of the results please fill out the form at the bottom of this letter and enclose it in the envelope along with the questionnaire.

Sincerely,

Janet Wimmer
Janet Wimmer
Graduate Student

Carolyn Moore
Carolyn Moore
Graduate Advisor

Please send me the results from your study.

Name ____________________________________

Address ____________________________________

____

____

EDUCATIONAL CAD USE QUESTIONNAIRE

Please check all answers that apply for each item.

1. Do your students use computer aided design (CAD) in any apparel design course(s) in your department?
___Yes (Please continue) ___No (Please return the questionnaire)

2. In what course(s) do you teach the use of CAD?
___basic flat pattern ___pattern grading ___CAD only
___advanced flat pattern ___other(specify) ______________________

3. What do you teach on the CAD system?
___digitizing ___pattern grading ___marker making
___flat pattern techniques ___pattern drafting ___garment sketching
___other(specify) ______________________

4. What year did you first offer CAD in the apparel design curriculum?
___before 1982 ___1984 ___1987 ___1990
___1982 ___1985 ___1988 ___1991
___1983 ___1986 ___1989 ___1992

5. What influenced your decision to include CAD in your courses? Number in the order of importance.
___industry needs ____faculty/programs at other universities
___existing equipment ___advice of apparel manufacturer
___specific funding for computers ___other(specify) ______________________

6. What type(s) of CAD system(s) are you using and how many workstations(ws) do you have for each system?
___IBM or compatible ____# ws ___Microdynamics ____# ws
___MacIntosh computer ____# ws ___ModaCAD ____# ws
___Lectra ____# ws ___other(specify) ______________________# ws

7. If using an IBM (or compatible) or MacIntosh computer what CAD software(s) are you using in your apparel design course(s)?
___AutoCAD ___PC Pattern ___ApparelCAD
___VersaCAD ___BetaCAD ___other(specify) ______________________

8. Why did you choose the hardware system(s) you now have?
___cost ___industry incentives ___advice of others
___donated equipment ___equipment already available
___other(specify) ______________________

9. What instructional aids are you using to teach students to use CAD in the design course(s)?
___tutorial developed by software manufacturer

___tutorial developed by the department

___tutorial/textbook(specify title)______________________________

___other(specify)______________________________

10. How do you interact with the apparel industry?
___do not interact ___advisory boards ___field trips

___trade shows ___other(specify)______________________________

11. How do you interact with industry related organizations? (e.g. TC^2, AAMA ASQC)
___do not interact ___attend conferences ___leadership roles

___member ___other(specify)______________________________

12. How do you interact with the CAD industry?
___do not interact ___attend trade shows ___user conferences

___training sessions ___cooperative effort of software development

___other(specify)______________________________

13. In the next 5 years what are your plans for CAD in apparel design courses?
___plan to increase CAD stations ___plan to increase CAD time in course(s)

___plan to upgrade hardware ___plan to upgrade software

___plan to purchase different hardware system(specify)______________________________

___plan to purchase different CAD software(specify)______________________________

___other(specify)______________________________

14. When did you acquire your last update(s)? (answer for each system checked in question 6)
hardware_________ software_________ specify system______________________________

hardware_________ software_________ specify system______________________________

hardware_________ software_________ specify system______________________________

15. What challenges have you met integrating CAD in your design course(s)?_______________

____

____

____

Appendix E

Table E.1
Student Attitudes Toward Computers

Item	Question Number	SA	A	N	D	SD
Technology helpful	2	2	1	0	0	0
Reduce importance of theIndividual	4	0	0	0	0	3
Help to be successful	7	3	0	0	0	0
Own a computer	11	3	0	0	0	0
High Salary	13	1	1	0	1	0
Status	15	1	1	1	0	0
Computer expertise important	17	0	2	0	1	0
Few understand computers	18	0	1	0	1	1
Computers make mistakes	19	0	1	1	0	1
Keep up with technological advances	20	2	1	0	0	0
Diffcult to learn a computer language	21	0	0	0	3	0
Prefer not to learn how to use computers	24	0	0	0	0	3
Prefer to use a wordprocessor than type	25	3	0	0	0	0
Never understand how to use a computer	27	0	0	0	0	3
Do not like to program VCR's & microwaves	29	0	0	0	2	1
Computers create unemployment	31	0	1	0	0	2
Computer is time consuming	33	0	0	0	1	2

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.2

Student Attitudes Toward Computer Technology in the Apparel Industry

Item	Question Number	SA	A	N	D	SD
U.S. having problems competing with imports	01	0	3	0	0	0
Computers speed up design	03	2	1	0	0	0
Manual patterns not needed	05	0	0	0	3	0
QR strategy to compete with imports	06	1	1	1	0	0
Computer use possible to design with flat pattern	12	2	1	0	0	0
CAD experience needed by me	22	2	1	0	0	0
CAD training needed for future designers	32	1	2	0	0	0

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.3

Times to Complete the Final Assignment in CT 6004

Procedures	Time in minutes for AutoCAD/ApparelCAD			Time in minutes for Lectra		
Student	1	2	3	1	2	3
Part I Dart Manipulation						
Shoulder dart to neck	19	18	20	13	5	
Bust dart to shoulder	13	25	25	13	12	
Combined dart	15	30	25	15	14	
Darts to flare	10	15	10	14	10	
Part I Alterations						
Lengthen	36	18	25	6	3	
Decrease bodice waist circum.	63	13	15	7	2	
Decrease skirt waist circum.	51	20	31	4	3	
Total time for Part I	207	139	151	72	65	105
Part II Pattern Work						
Add button extension	8	13		5	15	
Make facing	40	60		27	30	
Creating design lines/ separating pieces	127	120		270	30	
Add seam allowances	65	5		41	10	
Total time for Part II	240	198		343	85	
Part III Pattern Grading						
Establish grade rules	120	60		120	60	
Input into computer	NA	120		60	60	
Apply grade to pattern	170	120		180	60	
Check pattern to be sure grade has been applied correctly	275	15		25	15	
Total time for Part III	565	315		385	195	
Total time for Final Assignment	1012	652	-	800	345	-

Table E.4

Steps to Complete Part I of the Final Problem in CT 6004

Procedures	Number of steps for AutoCAD	Number of steps for Lectra
Dart Manipulation		
Move Shoulder dart to neck	24	20
Move bust dart to shoulder	24	20
Save	3	8
Convert skirt darts to flare	28	24
Save	3	8
Print	5	3
Alterations		
Bodice copy	6	
Lengthen waist	10	14
Decrease waist circumference	10	
Dimension to check	24	
Save	3	8
Skirt - copy	6	
Decrease Waist circumference	22	5
Dimension to check dimensions	12	
Save	3	8
Print	5	3
Total	188	121

Table E.5

<u>Steps to Complete Part II of the Final Problem in CT 6004</u>

Procedures	Number of steps for AutoCAD	Number of steps for Lectra
Designing with Darts		
Princess lines Back	20	21
Princess lines front	25	12
Save	3	8
Print	5	3
Adding design lines		
Add button extension	18	7
Make cut-on facing	18	24
Combine bust dart at waist		
Convert to gathers	28	18
Add seam allowances	135	12
Make front armscye facing	25	18
Orient grainline		6
Add seam allowances	42	12
Make back armscye facing	25	18
Orient grainline		6
Add seam allowances	42	12
Make back facing	25	18
Orient grainline		6
Add seam allowances	37	12
Subtotal	448	213

Table E.5 (continued)

Steps to Complete Part II of the Final Problem in CT 6004

Procedures	Number of steps for AutoCAD	Number of steps for Lectra
Adding design lines (cont.)	448	213
Make yoke design line/separate pieces	10	10
Move back shoulder dart to neckline	25	10
Convert waist dart to gathers	8	10
Make yoke design line/separate pieces	10	10
Fuse/butt shoulder line	26	6
Orient grainline		6
Add seam allowances	73	12
Add seam allowances to back	73	12
Save all pieces	3	8
Plot/print	5	3
Total	681	300

Table E.6

Steps to Complete Part III of the Final Problem in CT 6004 Using AutoCAD/ApparelCAD

Procedures	Number of steps for AutoCAD
Bodice front to size 14	
Copy	8
Divide bodice in segments	25
Break points to grade	60
Stretch (9 steps x 9 sections)	81
Dimension	
Original	36
Graded	36
Bodice to size 10	
Copy	8
Divide in segments	25
Break points to grade	25
Stretch (9 steps x 9 sections)	81
Dimension	
Graded	36
Bodice back to size 14	
Copy	8
Divide bodice in segments	25
Break points to grade	60
Stretch (9 steps x 9 sections)	81
Dimension	
Original	36
Graded	36
Subtotal	667

Table E.6 (continued)

Steps to Complete Part III of the Final Problem in CT 6004 Using AutoCAD/ApparelCAD

Procedures	Number of steps for AutoCAD
Pattern grading continued (Subtotal)	667
Bodice back to size 10	
Copy	8
Divide in segments	25
Break points to grade	25
Stretch (9 steps x 9 sections)	81
Dimension	
Graded	36
Yoke	
Divide into segments	12
Break points	12
Stretch (9 steps x 3 segments)	27
Dimension	
Original	36
Graded	36
Save	3
Print/plot	5
Total	973

Table E.7

Steps to Complete Part III of the Final Problem in CT 6004 for Lectra

Procedures	Number of steps for Lectra
Set up to apply grade rules	
Exit, exit, exit	3
LGP	1
BI, Basic Design	2
Name & arrow through	6
/ & enter name	2
Presentation	5
Apply grade rules	
Get to MIB	16
Front	
Apply grade rules to grade points	7
Eight additional grade points (8 x 7)	56
Nest	3
Save	8
Plot	3
Repeat process for back yoke (5 x 7)	35
Repeat process for back bodice (5 x 7)	35
Nest	3
Save	8
Plot	3
Total	196

Note: The process of filling out the grade rule sheet for Part III of this assignment takes approximately two hours. Each grade point must be set up on the x,y axes in 32nds of an inch (ex. -4,2 for moving the shoulder point 1/8" in the -x direction and 1/16" in the y direction). Bodice pattern pieces are oriented with the center along the x axis and the shoulder on the y axis. The neck is to the left and the waist to the right. Therefore, the same grade rules can be used for common points on the back and front bodices and do not have to be rewritten. After the grade rules have been written, they can be applied via the computer.

Table E.8

Student Attitudes Toward CT 6004

Item	Question Number	SA	A	N	D	SD
Put forth an effort to do well in CT 6004	10	2	1	0	0	0
Expect to earn at least a B	16	2	1	0	0	0
CT 6004 is my favorite class	30	1	0	2	0	0

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.9

Importance of Subject Matter in CT 6004

Items	Question Number	SA	A	N	D	SD
Learning CAD will enhance my Design Ability	14	2	1	0	0	0
Important skills for design students is - Manual flat pattern techniques	28	0	2	1	0	0
Important skills for desing students is - computer flat pattern techniques	34	0	2	1	0	0

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.10

Student Attitudes Toward Computers as Instructional Tools

Item	Question Number	SA	A	N	D	SD
Like to use computers	08	3	0	0	0	0
Be able to work at own pace	09	1	2	0	0	0
Computer activities are exciting	23	3	0	0	0	0
Wish for more computer activities	26	1	2	0	0	0

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.11

Advantage(s) of Doing Dart Manipulation using the two CAD systems

Advantage(s) of AutoCAD/ApparelCAD for dart manipulation
The ability to rotate darts is very similar to the pivot method of hand dart manipulation which is my personal preference for hand dart manipulation.
Ability to use the window to work in specific areas.
The sloper stays in one piece during the procedure.
Advantage(s) of Lectra for dart manipulation
The Lectra employs a cut and fusion method similar to the slash and spread method for hand dart manipulation. The Lectra plots patterns that can actually be used. The advantage of having usable patterns that can be sewn into trial garments outweighs any advantages by any other system.
Cut and fusion is quick and somewhat easy.
The Lectra is faster.

Table E.12

Advantage(s) of Doing Alteration Problems using the CAD systems

Advantage(s) of doing alteration problems on AutoCAD/ApparelCAD
The stretch process for making alterations is a disadvantage not an advantage. The steps involved require an excess of steps and time to execute these steps.
Stretch command allows user to work in sections.
No advantage above the Lectra but many above manual.
Advantage(s) of doing alteration problems on Lectra
It is so easy to alter patterns with the Lectra system that there is no real comparison. Lining can be used to lengthen and cut can be used to decrease. I prefer the Lectra for alterations as well as the ability to print usable patterns.
Ability to work quickly, and move grade points at the waistline without altering the hipline.
The Lectra is quicker, done in one procedure. It is easier to compare changes.

Table E.13

Advantage(s) of Doing Pattern Design Work on the CAD systems

Advantage(s) of doing pattern design work on AutoCAD/ApparelCAD
The AutoCAD system seems to be a more hardy and durable system which makes it more dependable. If a real job deadline was in question, I would choose the most dependable equipment possible. The AutoCAD system would also be more practical if teaching a class involving problem set as time consuming as Part II. This system is more accessible to students; and the advantage of five stations allows more than one student to complete work at the same time interval.
The seam allowances are somewhat easy to do.
None, and the work looks choppy; may be better with an updated system.
Advantage(s) of doing pattern design work on the Lectra
The Lectra was non functional twice during the time I completed Part II. I did not record down time. However, some of the recorded time includes repeated recreations of the same pattern pieces. Even with time needed for repeated work, the Lectra system allows the designer to complete design tasks more efficiently. The Lectra is much easier to use for creating facings and seam allowances. The Lectra also has the advantage of being able to print usable patterns.
The facing and button extension fairly easy to do.
The work is cleaner, the lines and curves can be manipulated and separation and movement of piece changes much better than AutoCAD.

Table E.14

Advantage(s) to Pattern Grading using the two CAD systems

Advantage(s) to pattern grading on AutoCAD/ApparelCAD
The only advantage in grading patterns on AutoCAD is the ability to use any fraction to stretch a pattern to graded size.
None. The grading is difficult because its hard to see the results and the dimensioning isn't accurate due to the point for measurement.
None with the presently available version. For someone who has trouble with writing grade rules it might be valuable.
Advantage(s) to pattern grading on the Lectra
Advantages include the ability to create useable patterns, to create many nested grades with one set of grade rules and basis operations, and the ability to check grading accuracy on screen before printing.
Much easier to see and understand what is going on while I was working, there was a problem, but the solution wasn't hard to figure out.
The slowest thing about using the Lectra for grading is writing the grade rules, actually using the program is easy.

Table E.15

Attitudes Toward Using AutoCAD/ApparelCAD

	Question Number	SA	A	N	D	SD
Had no problem understanding the CAD activity	35	1	0	1	1	0
The CAD activity was appropriate to CT 6004	36	1	2	0	0	0
Easy to visualize pattern piece from information on the screen	37	2	0	0	1	0
Projects took a reasonalble amount of time	38	0	0	0	2	1
I felt adequately prepared to use the CAD systems	39	1	1	0	1	0
The graphics were clear	40	2	1	0	0	0
I like the idea of using the computer for flat pattern	41	1	0	1	1	0
I will use the skills learned in CT 6004	42	1	1	0	1	0
The CAD activity made me more aware of the importance of accuracy	43	1	1	0	1	0
I enhanced my knowledge of flat pattern techniques using CAD	44	1	1	0	1	0

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.16

Attitudes Toward Using Lectra

	Question Number	SA	A	N	D	SD
Had no problem understanding the CAD activity	35	1	1	1	0	0
The CAd activity was appropriate to CT 6004	36	2	1	0	0	0
Easy to visualize pattern piece from information on the screen	37	2	1	0	0	0
Projects took a reasonalbel amount of time	38	0	2	0	1	0
I felt adequately prepared to use the CAD systems	39	2	1	0	0	0
The graphics were clear	40	2	0	1	0	0
I like the idea of using the computer for flat pattern	41	2	1	0	0	0
I will use the skills learned in CT 6004	42	3	0	0	0	0
The CAD activity made me more aware of the importance of accuracy	43	1	1	0	1	0
I enhanced my knowledge of flat pattern techniques using CAD	44	3	0	0	0	0

N = 3
SA = Strongly Agree A = Agree N = Neutral D = Disagree SA = Strongly Disagree

Table E.17

Factors that Influenced the Decision to Include CAD in Apparel Design Courses

Factors	Rank order 1	2	3	4	5	6	Checked but not ranked	Total
Industry Needs	31	3	2	0	0	0	12	48
Faculty/Programs at other universities	6	12	6	3	0	0	4	31
Existing Equipment	2	1	4	4	1	2	3	17
Advice of apparel manufacturer	0	8	3	0	4	0	8	23
Specific funding	4	5	4	2	3	0	1	19
Working with CAD vendor	0	0	0	0	0	0	1	1
Advice of Advisory Board	0	1	0	0	0	0	0	1
Students need computer experience	0	2	0	0	0	0	0	2
Interest of the professor	0	1	0	0	0	0	0	1
Computer technology is so prevalent	1	0	0	0	0	0	0	1
Prepare students	0	0	0	0	0	0	1	1
Faculty with CAD knowledge	0	1	0	0	0	0	1	2

Appendix F

RESPONDENTS INTERACTION WITH THE APPAREL INDUSTRY INDUSTRY RELATED ORGANIZATIONS, AND THE CAD INDUSTRY

The need for interaction between apparel design programs and the apparel industry was emphasized in the review of literature ("Automation makes", 1984). The respondents were asked how they were interacting with the apparel industry, related industry organizations (e.g. TC^2, AAMA, ASQC), and the CAD industry. The results show that apparel design programs interact in a variety of ways with these industries. The most frequent type of interaction with the apparel industry were advisory boards, field trips, and trade shows (Table F.1). The most popular method for interacting with industry related organizations (e.g. TC^2, AAMA, ASQC) was attending conferences and holding membership in these organizations (Table F.2); however, 16 respondents indicated no interaction with industry related organizations. Respondents also interacted with the CAD industry. This activity included trade shows, user conferences, training sessions, cooperative effort with software vendor, and other. The two most frequent types of interaction were trade shows and training sessions (Table F.3).

Table F.1

Interaction with the Apparel Industry

	Frequency	Percent %
Do not interact	3	2
Advisory board	26	17
Field trips	**55**	**37**
Trade shows	34	23
Other	32	21
Total	150	100

Table F.2

Interact with Related Industry Organizations

Activity	Frequency	Percent %
Do not interact	16	20
Attend conferences	**29**	**36**
Leadership	6	7
Member	13	16
Other	14	17
No response	3	4
Total	81	100

Table F.3

Interaction with CAD Industry

Activity	Frequency	Percent %
Do not interact	11	10
Trade shows	**32**	**28**
User conferences	20	17
Training session	**33**	**29**
Cooperative with software vendor	7	6
Other	10	9
No response	2	2
Total	115	100

Limited stations, so lots of open lab time for students no or limited supervision - just good directions.

Working first without a CAD system- driving to Dallas or Irving for class- then working without a plotter, Now working without a digitizer - We also use Microdynamics at another university. We believe so strongly in CAD that we won't give up.

User space and time available to students in an overbooked campus CAD lab. Have not received funding for our own CAD hardware because we are too small a program.

The hardest part of this adventure was convincing others of our need to integrate CAD in fashion design.

Have been integrating CAD for over 10 years - The most difficult aspects are keeping workbooks (MD, PDS, GMS, and now PDM) and myself up-to-date. This is particularly time consuming! Securing funding to keep hardware capability up-to-date with software.

Since we only have 5 workstations it is difficult to accommodate large groups of students.

Hard for students to get CAD pre req and flat pattern pre req to my ApparelCAD class (some in class with CAD experience and some without - different levels) Need advanced CAD class but no room in program - would need to eliminate something else - small classes and university wants bigger class numbers.

Acquiring fund to purchase software and equipment (stations) was the greatest challenge.

Finding the "time" to integrate along with other information.

(1) Training the instructor(s)
(2) Training TA support
(3) Teaching 20 students each semester on only 10 stations
After 3 years research on equipment (systems) and software, I am delighted to see that our choices have been highly successful. The classes are full, with waiting lists each semester. The students are able to learn to be proficient on the computer in the 18 week semester @ 3 hours a week. (Some students came in for additional lab hours.)

Equipment which is not always in operating order.

Time it takes for students to get proficient with software manipulations. Not having enough faculty who spend the time to learn the computer and its applications.

Scheduling small group lab time because of limited stations.

Students response has been excellent, high level of interest, class enrollment limited, so waiting for availability. Pre req. requirement: flat pattern or co-reg of flat pattern - Personal

challenge - keeping up myself - need to share with others teaching. Would love a handbook of tutorials!
personal phil: Better to expose students to some CAD - even just AutoCAD - than nothing. They had be trained to any system, but still will know concepts, limitations, adaptations, etc. from the course - 2 days a week - 3 hours per class 3 credit (term).

Getting qualified instructors.

Funding/partnership with Microdynamics - Funding for lab for apparel and merchandising students (currently we use/share a college lab) - time to train/learn new software.

These are minor compared to what we've accomplished in the last several years. 1.) Timing problems - what to leave out of existing program
2.) All faculty have not learned system yet
3.) Equipment breakdowns.

Being told we couldn't do it by the people who set up the computers; now it is convincing them to answer specific user questions re:AutoCAD 12 so that we can grow in our own apparel design applications.

Making time for all students to have enough time to get assignments finished. Each class has had 15+ enrollment with each student assigned 3 hours of computer lab time. We use the (flat) pattern design class as a pre-requisite to the computer pattern design class.

Allowing students to work in the lab outside of class is costly. Supervision is costly and at a minimum.

This is the first time offered. We're in the 2nd week of classes students are apprehensive; new hardware on LAN is giving us technical glitches. Have used AutoCAD in Visual Merchandising for store layout for past 2 years.

Machines must have math co-processors; only one color plotter.

1. Scheduling: lab must be monitored for security, 2. Students tend to think of it as a "class" not a "tool", so revert to old habits in other classes e.g. in apparel production students are encouraged to develop patterns and markers on the computer and are capable of it but choose to do it by hand quite often.

Horrible software - slow hardware - making "room" for CAD in an existing course often means bumping something else.

Money.

1. Computer literacy of students
2. Learning to draw with the mouse.

We are just starting with special studies; we need more computers for the program to develop. Funds are limited.

The biggest problem has been finding the time to develop tutorials and also juggling students working on CAD while others in the same class are involved in other activities. This is necessary with only 2 stations. Another problem has been the upkeep of the system. We do not have anyone employed as a computer lab technician to coordinate service, ordering of supplies, etc..

It is very time consuming for an instructor to get trained on a system and to be efficient with the system. (In terms of students' acceptance, there was no problem).

Software documentation, hardware compatibility.

Finding funds for updates.

Number of students to number of workstations - much outside lab one on one time professor with each student - work in pairs to maximize time.

Attitudes of program director who does not believe in the necessity of CAD training for students.

Adequate instructional materials and a consensus of industry needs.

Time for students to use computers outside of class, development of assignments - due to differences in students' computer knowledge.

Getting part time instructors involved in using the systems, finding money for the systems.

Having enough work stations for students, managing open labs, finding operating and maintenance funds, finding appropriate course materials, e.g. texts.

Enough student time on shared machines (5 stations - 15 students each class).

Student demand is greater than number of workstations. Student background and expertise varies widely! No money for equipment repair. Technology changes very rapidly!

Lack of appropriate tutorials; hardware and software support on campus.

Money for industry system.

Requiring assignments when we lack sufficient workstations, and lack sufficient time on the quarter system. Also, having to teach myself most of what I know on CAD, then teach the students!

No release time to develop course and materials. No funding for equipment. CAD is not a required course.

Cost - No commitment from administration.

Students need to take basic AutoCAD before having course.

Knowing what industry wants and where to find it in the program.

Attempting to implement it in several courses - accessing more equipment.

Time consuming and inconvenient to use.

Limited work stations - Inadequate faculty training/time to hone computer skills- Fortunate in having Lab Specialist with computer knowledge and skills.
Technology and network breakdowns, incompatibility

Adequate open lab time; hardware and software upgrades; fully integrating CAD into curriculum due to the amount of time required to learn basic AutoCAD commands - thus we have one course rather than several courses with CAD components as we orginally thought would be possible; faculty equipped to teach is a problem as well.

Getting enough time for students to use equipment.

Teaching only upper level CAD courses but integrating CAD at all levels. Trying to teach CAD to several disciplines in a single course.

VITA

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Janet R. Wimmer

INTEGRATION OF CAD TECHNOLOGY

IN APPAREL DESIGN CURRICULA

by

Janet Wimmer

Committee Chairman: Valerie L. Giddings
Clothing and Textiles

(ABSTRACT)

The purposes of this study were to assess student attitudes toward CAD technology and use, to determine the efficient use of computer aided design (CAD) systems in the design curriculum, and to investigate the current use of CAD at other colleges and universities in the United States with apparel design programs.

A questionnaire was administered to students enrolled in a computer aided design course to determine previous computer experience, previous design courses taken and attitudes toward the use of computers. Another questionnaire that focused on the students attitudes toward the two CAD systems used in the class was administered after completion of the final assignment. The students in the apparel design course had positive attitudes toward computers and the usage of CAD as a tool for design applications. The students preferred to use the Lectra system and felt that it was the most efficient CAD system to use for assignments in the apparel design course. However, further study needs to be conducted concerning the efficient use of CAD in apparel design courses.

A questionnaire was mailed to faculty at universities with apparel design programs to determine how CAD was being used in the curriculum, the type(s) of CAD system(s) being used, and the future plans for CAD in the curriculum. Frequency and percentage distributions were used to analyze the data. The data collected from educators teaching CAD at other colleges and universities in the United States indicate that CAD is being used in the classroom to teach flat

pattern techniques (18%), pattern grading (16%), and marker making (16%). Thirty three apparel design programs were using IBM computers to teach CAD with 14 programs using MicroDesign equipment to teach CAD. The programs that were using IBM computers or compatibles were using AutoCAD software (39%).

The results also showed a significant increase in the number of programs with CAD in the curriculum from 21 between 1982 and 1989 to 38 between 1990 and 1993. This indicated that apparel design programs realized the importance of integrating CAD into the design curriculum to better prepare students for employment in the apparel industry.